ELECTRICAL ENGINEERING

DECEMBER 1959
Vol. 78, No. 12

Contents

A Salute to the American Institute of Electrical Engineers — *R. M. Blough* — 1151

The Institute and Philadelphia: 1884 — *L. F. Hickernell*
An historical review of the events that formed the background for the first technical meeting of the Institute 75 years ago in Philadelphia — 1152

Peripheral Professional Problems of Engineering Management — *C. F. Savage*
Because the engineering manager is responsible for assuring optimum utilization of all facilities, his attention must be directed to many areas — 1160

Vickers Vanguard Electrics — *Harry Zeffert*
The electric system of the British Vickers Vanguard, new turbo-prop airliner now being flight-tested for service in 1960 — 1164

Improved Standardization Procedure as Developed for Lightning Arresters — *G. F. Lincks*
A new standardization procedure that will keep one American Standard on Lightning Arresters continuously up-to-date — 1169

Solar-Powered Thermoelectric Generator Design Considerations — *N. F. Schuh, R. J. Tallent*
A description of some of the problems that will be encountered in a solar-powered thermoelectric generator for space vehicles — 1172

The Design and Manufacture of Direct Burial Wire — *J. L. Robb, W. L. Roberts*
In areas where high-speed wire plows can be used, direct burial wire compares favorably in cost with open wire construction — 1178

Linear-Phase Transistor Amplifier — *Peter Hirsch*
Theoretical background and experimental techniques involved in the design of a linear-phase transistor amplifier are outlined — 1184

The Effect of Elevated Temperature on Flash-Welded Aluminum-Copper Joints — *C. R. Dixon, F. G. Nelson*
Techniques to improve the quality of flash-welded joints between aluminum and copper have been so successful, they can now be made commercially — 1190

Utilities Radio Regulation and Technical Advances — *J. C. Slothower*
Interrelationships between governmental regulatory bodies and advisory committees formed by groups of radio users are discussed — 1196

A New Electrical Research Laboratory — *F. E. Andrews, Alex Vitkus*
This laboratory is for the development and engineering of electrical and line construction products for transmission and distribution systems — 1200

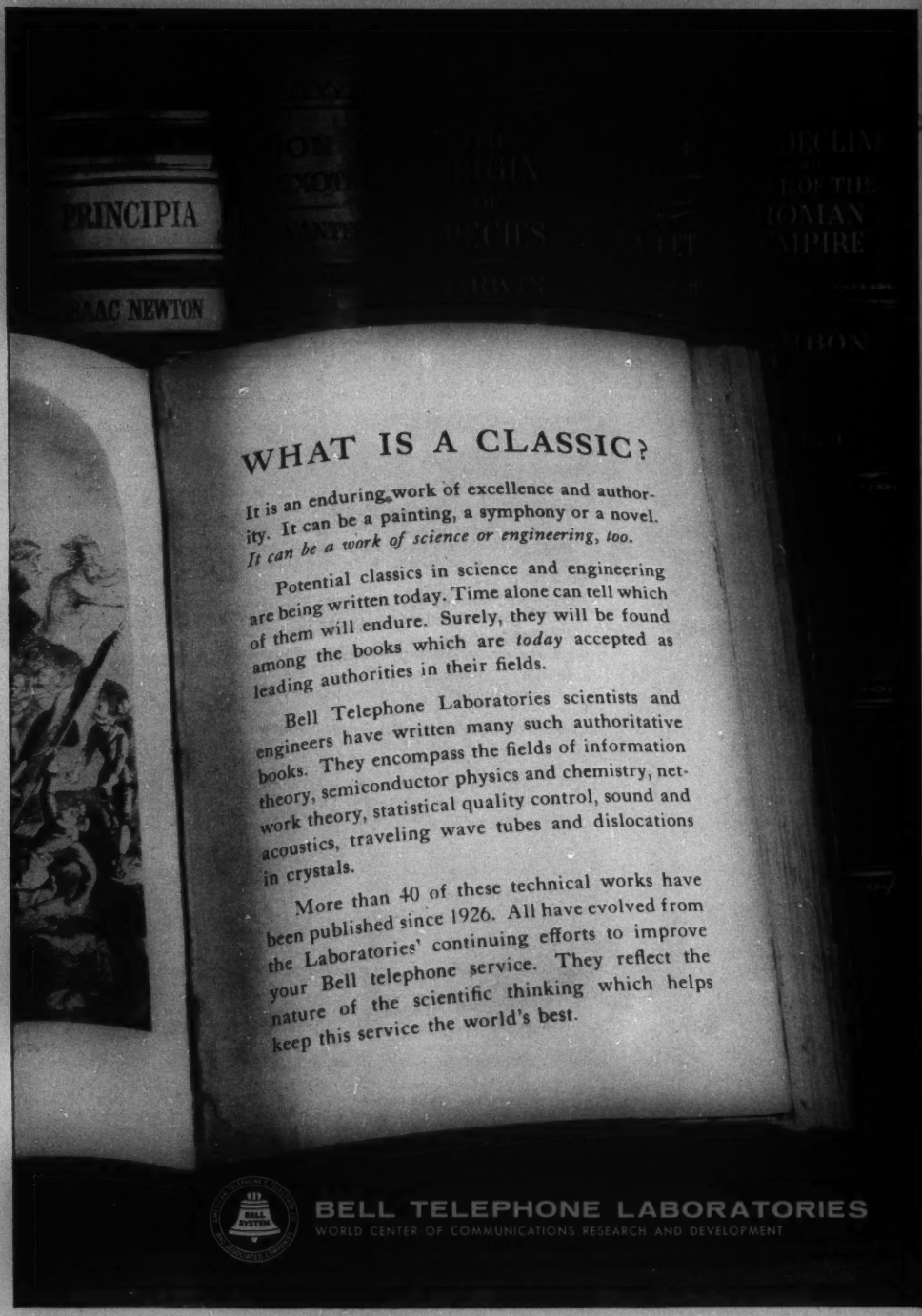
CONTENTS CONTINUED

Published monthly by American Institute of Electrical Engineers

ELECTRICAL ENGINEERING: © Copyright 1959 by the American Institute of Electrical Engineers; printed in the United States of America; indexed annually by the AIEE, weekly and annually by *Engineering Index*, and monthly by *Industrial Arts Index*; abstracted monthly by *Science Abstracts* (London). Address changes must be received at AIEE headquarters, 33 West 39th Street, New York 18, N.Y., by the first of the month to be effective with the succeeding issue. Copies undelivered because of incorrect address cannot be replaced without charge.

THE COVER: High-voltage high bay area of Hubbard and Company's Electrical Research Laboratory at McCook, Ill. In the foreground is the high-current surge generator, with energy rating of 80 kilowatt-seconds at 100,000 volts. Story on p. 1200.

75th Anniversary
A I E E
1884 — 1959
75 Years
A Prologue to the Future



WHAT IS A CLASSIC?

It is an enduring work of excellence and authority. It can be a painting, a symphony or a novel. *It can be a work of science or engineering, too.*

Potential classics in science and engineering are being written today. Time alone can tell which of them will endure. Surely, they will be found among the books which are *today* accepted as leading authorities in their fields.

Bell Telephone Laboratories scientists and engineers have written many such authoritative books. They encompass the fields of information theory, semiconductor physics and chemistry, network theory, statistical quality control, sound and acoustics, traveling wave tubes and dislocations in crystals.

More than 40 of these technical works have been published since 1926. All have evolved from the Laboratories' continuing efforts to improve your Bell telephone service. They reflect the nature of the scientific thinking which helps keep this service the world's best.

BELL TELEPHONE LABORATORIES
WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

Contents Continued

Technical Paper Digests

Liquid Dielectrics in an Electric Field	*W. H. Middendorf, G. H. Brown*	1158
Load Characteristics of a Smelting Furnace	*George Grant III*	1159
The Internal Insulation of Generator Coils	*D. A. Findlay, R. G. Brearley, C. C. Louttit*	1168
Motorette Evaluation of Insulation Systems	*H. P. Boettcher*	1177
Subtransient Reactances of Synchronous Machines	*K. B. Menon*	1183
Induction Motors with Permanent Magnet Excitation	*J. F. H. Douglas*	1195

Departments

Abstracts of AIEE Technical Papers	1205
Institute Activities	
AIEE Celebrates 75th Anniversary of the Institute's First Technical Meeting	1207
AIEE Future Meetings	1209
Detailed Arrangements Made for 1960 AIEE Winter General Meeting	1210
Outstanding Young Engineers of 1959 Are Named by Eta Kappa Nu	1211
1,900 Members and Guests Attend Fall General Meeting in Chicago, Ill.	1212
Business Conducted by Directors at Fall General Meeting in Chicago, Ill.	1216
Operational Problems Considered at Forum of Technical Committee Chairmen	1218
United Engineering Center	1219
Cooper Union Marks 100th Year	1221
Los Angeles Section Hears About New Jetliner	1222
AIEE Fellows Elected	1225
AIEE Personalities	1228
Obituaries	1228
AIEE Section and Student Branch Meetings 1958-1959	1229
Of Current Interest	
Automated "Tutor" Ensures Active Student Participation	1232
Future Meetings of Other Societies	1233
Earth-to-Space "Ferry" Designed To Carry Astronauts	1234
Electric "Bridge-Building Machine" To Help Span Lake Maracaibo, Venezuela	1235
Giant Telescope Mirror Sent to Kitt Peak Observatory	1236
Power Station Is Built Underground	1237
Fuel Cells Used To Power Experimental Tractor	1239
"Handwriting Reader" Has a 10-Word Vocabulary	1241
New Books	1243
Technical Literature	1244
New Products	18A
Industrial Notes	38A
Trade Literature	58A

Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

Headquarters, 10th floor • Editorial Offices, 6th floor

33 West 39th Street, New York 18, N. Y.

J. H. FOOTE, President — N. S. HIBSHMAN, Secretary

PUBLICATIONS DEPT., W. F. Denkhaus, *Chairman*; H. N. Muller, *Vice-Chairman*; C. S. Rich, *Secretary*; E. W. Boehne, D. T. Braymer, T. H. Cline Burke Frick, L. R. Gaty, Lenine Gonsalves, E. I. Green, E. T. B. Gross, W. R. Harris, C. T. Hatcher, D. L. Hemmenway, W. S. Hill, A. W. Kessler, C. W. Leiby, M. S. Merritt, F. W. Norris, F. C. Roberts, J. D. Tebo, J. J. Tesar, B. J. Wilson, P. G. Wallace

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office Hildreth Press, Bristol, Conn. Editorial and advertising offices 33 West 39th Street, New York 18, N. Y. Member subscription $6 per year nondeductible from dues; single copy 75 cents. Nonmember subscription $12 per year plus extra postage to all countries to which second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Bristol, Conn., under the Act of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. December 1959. Vol. 78, No. 12. Number of copies this issue, 65,000.

Charles S. Rich
Editor and Manager of Publications

G. C. Baxter Rowe
Associate Editor

Editorial Assistants

G. Charitz

A. M. Fallert

G. Jaari

E. Jacobs

S. Walters

R. E. Whitlock

Advertising

J. S. Lopes
Middle Atlantic Manager
33 W 39 St., New York 18, N.Y.
Tel: PEnnsylvania 6-9220

J. S. Holzer
Eastern Manager
33 W 39 St., New York 18, N.Y.
Tel: PEnnsylvania 6-9220

E. R. Bollinger
Central Manager
3758 Cleveland-Massillon Rd.
West Richfield, Ohio
Tel: OLiver 9-4800

A. E. Del Gado
Mid-West Manager
1604 Chicago Ave.,
Evanston, Ill.
Tel: UNiversity 9-2288

T. P. Galavan

A. O. Dillenbeck, Jr.
Western Adv. Office
266 South Alexandria Ave.
Los Angeles 4, Calif.
Tel: DUnkirk 5-3991

J. C. Brettman
Southern Adv. Office
1915 E Sunrise Blvd.
Fort Lauderdale, Fla.
Tel: IA 2-6930

Waldo Schraubstader
Market Research Director

Frances Newman
Advertising Production Manager

ABC
Member
Audit Bureau of Circulation

The revealing face of an iron crystal

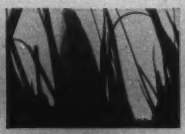
A single crystal is an ideal system for studying the solid state. Physicists at the General Motors Research Laboratories have turned to whisker-like growths of nearly perfect single iron crystals to investigate three intriguing phenomena: magnetic domains, dislocation defects, and—more recently—high temperature oxidation.

In this latest study, the two crystallographically different surfaces found on iron whiskers are being used to examine the anisotropy or axial-dependent nature of the oxidation process. In early stages of oxidation, the oxide patterns that form on clean surfaces have been found to be strongly dependent upon the orientation of the underlying crystal. In later stages of oxidation, tiny oxide "cilia" actually grow on the surface of the iron whisker. But these new whiskery forms of oxidation are no longer related to the crystal's surface arrangement. The next step in this program involves correlating the oxidation behavior with lattice structure defects such as vacancies and dislocations.

This type of solid state research is revealing the atomic processes underlying strength, magnetic characteristics, and corrosion resistance of metals. At GM Research, we believe the solution to practical problems is increasingly dependent on fundamental information such as this. And each solution enables us to continue to provide "More and better things for more people."

GENERAL MOTORS RESEARCH LABORATORIES

Early Oxidation
(750x)



Oxide Whiskers
(12,000x)

Reduction of Oxide Products
(2500x)

Courtesy Karsh, Ottawa

A Salute to the American Institute of Electrical Engineers

When we consider the milleniums through which man struggled feebly, with firebrands, coals, and candles, to push back the walls of darkness, the enlightened years since Thomas Edison's discoveries seem brief indeed.

The electrical engineer is Edison's heir, and, thanks largely to his efforts, in three quarters of a century we have emerged fully from the Age of Steam, entered the Age of Electronics, and now stand, bold and expectant, on the threshold of the Age of Outer Space.

It would take volumes to recount the blessings that have flowed from the wedding of electricity and manufacturing. Electrical inventiveness has given the steel industry those aristocrats of metallurgy—electric-furnace stainless, heat resistant, and other alloy and tool steels; also motor-driven mills, cranes, and a myriad of drives and controls by which we have modernized our operations; and the electrolytic coating of steel with tin that has made a giant of the modern canning business.

Steel, in turn, has given the electrical engineer the silicon, alloy, and constructional steels for electrical equipment that have helped public utilities cut the cost of residential current in half over the last 25 years.

The happy marriage of science and industry has lately conceived the possibility of steel many times the strength of the strongest steel existing today. We can now envision electronically controlled steel projectiles capable of transporting man beyond the moon—into the far reaches of space—the world of opportunity for tomorrow.

Roger M. Blough

Chairman of the Board
United States Steel Corporation

75 Years—
A Prologue to the Future

The Institute and Philadelphia: 1884

L. F. HICKERNELL

AIEE PRESIDENT, 1958-59

A review of some of the events of national and international significance that formed the background and partially inspired the first technical meeting of the Institute 75 years ago in Philadelphia.

THE American Institute of Electrical Engineers was organized in a most unprepossessing year for the United States, a year of economic and industrial depression. Newspaper headlines in mid-May, the time of our Institute's formation, told of a financial panic. In times of adversity, the resilience of the American spirit manifests itself. 1884 was no exception.

Practice of strict economy enabled many firms to ride out the depression. With employment in industry low, labor was diverted to railroad building. Cattle ranching increased. Greater attention was focused on agriculture, and an unprecedentedly heavy crop was harvested.

Among people in the news was Grover Cleveland, who defeated James G. Blaine for the presidency by a scant majority of 23,000 popular votes. To General Ulysses S. Grant, 1884 brought both bankruptcy and the knowledge that he was incurably ill of cancer. Perhaps symbolic of the nation's will to triumph over hardship was the personal courage shown by Grant in accepting these blows. To provide for his family, he set about writing his memoirs, working diligently day after day, completing the task just 4 days before his death in July 1885. Published in 2 volumes, the autobiography won critical acclaim, both for character of writing and historical contribution, and brought Mrs. Grant $450,000 in royalties.

THE CENTENNIAL EXPOSITION

THE UNITED STATES had gained international prestige in 1876 by hosting a World's Fair in celebration of her 100th birthday. For the United States exhibit at the fair, it had been necessary to review and gather evidence of her accomplishments in all fields. The past lay tidily documented.

Visitors to the 1876 Exposition could—with some effort—find displayed a few electrical devices. To some, including young Philadelphian Elihu Thomson, these were the only items of future importance. Passing over such spectacular displays as the world's largest steam engine, Thomson returned again and again to the inconspicuous, poorly attended French Gramme dynamo exhibit, which he was to recall vividly on his 80th birthday, 57 years later. Thomson took advantage of opportunities to converse with Alexander Graham Bell, who was on hand to demonstrate his invention of only 6 months before, the telephone.

Thomson, then head of chemistry at Philadelphia's Central High School, had the previous year operated the first radio set in history, sending sound a distance of 100 feet. By his own admission in later years, he had not been wise enough to exploit the discovery. However, there was to be ample room—and time—for Thomson to win approbation for his inventions in the electric power field, to which he turned his considerable talents. Thomson served as AIEE President in 1889-90, and received the first Edison Medal in 1909.

ELECTRICITY TO 1884

IN THE BOARD ROOM at AIEE Headquarters is hung a large oil painting of "Dr. Wm. Gilberd shewing his experiments on electricity to Queen Elizabeth and her court," given us by the British Institution of Electrical Engineers in 1904. The painting marks the point in electrical history where knowledge of certain magnetic phenomena gave way to experimental investigation.

Dr. Gilbert is credited with origination of scientific research in 1600 with publication of his book entitled, "On the Magnet, Magnetic Bodies and the Great Magnet, the Earth," which came to the Institute in the Wheeler gift of the Latimer Clark Library.

The history of electrical development to 1883 has been classified into three eras:

1. *Frictional Electricity*. From the discovery of the electrical properties of amber in 600 B.C. by Thales to the experiments about 1750 by Benjamin Franklin.
2. *Battery Current*. From the invention of a primary battery (Voltaic pile) in 1800 by Alessandro Volta.
3. *Electric Power* (dynamos). From the discovery of electromagnetic induction in 1831 by Michael Faraday and Joseph Henry.

By 1884, several practical applications of electricity and magnetism had been made by inventors, particularly in the field of telecommunications, power, and illumination.

ELECTRICAL EXHIBITION PLANNED

NEWS of The Franklin Institute's plan to hold an International Electrical Exhibition was welcomed with enthusiasm by American inventors, electrical experts, and manufacturers. They were convinced that utilization of electricity would lead to industrial achievement, to prosperity and pleasant living conditions. Public

Full text of an address presented in abstract at a dinner meeting celebrating the 75th anniversary of AIEE's first technical meeting, The Franklin Institute, Philadelphia, Pa., Oct. 7, 1959; and at the general session of the AIEE Fall General Meeting, Chicago, Ill., Oct. 11-16, 1959.

L. F. Hickernell is vice-president-engineering at the Anaconda Wire and Cable Co., Hastings-on-Hudson, N. Y.

acceptance of these beliefs had yet to be obtained. Here would be an opportunity to seek it, and at the same time to demonstrate their capabilities to skeptical counterparts in foreign countries.

The site chosen for the Exhibition was the very spot in Philadelphia where Benjamin Franklin had sailed his kite and drawn a spark from a cloud 130 years before. The Franklin Institute borrowed funds to finance the Exhibition, including erection of the main building. Fig. 1 shows a ground plan of the Exhibition.

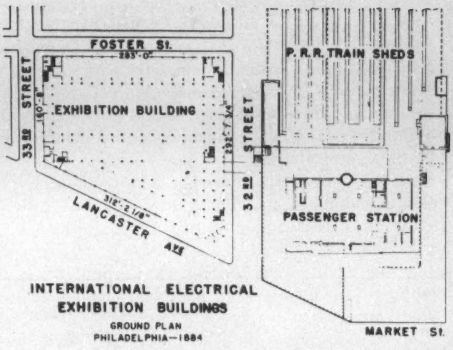


Fig. 1. Ground plan of exhibition buildings. (Redrawn from *Electrical World*).

THE EXHIBITION BUILDINGS

In Fig. 2 the main building appears at the left. It was a wooden structure, painted yellow. The central arch seen across the rear was a 100-foot span, 200 feet in length. The buildings provided 200,000 square feet of space for exhibits. Along the Foster Street side was a boiler house in which 20 steam engines of novel design propelled the building's electrical machinery.

On the right in Fig. 2 may be seen the old Pennsylvania Railroad Depot, acquired when additional space became a necessity. A footbridge was built across 32nd St. to permit direct access to the second floor of the main building. The waiting room of the depot became a lecture hall, with huge maps painted on its walls. Two of these maps showed the location of all ocean cables, in use or abandoned.

The shedding area in the rear of the property was used for such exhibits as motors, and railroad switches with signals.

The railroad refused to allow new-fangled electric lighting in its buildings, and the Exhibition suffered the ignominy of being in part lighted by illuminating gas.

EXHIBITS SOUGHT

Exhibits were invited in seven general categories: production of electricity, electric conductors, measurements, high- and low-power apparatus, terrestrial physics, historical apparatus, and educational and bibliographical.

Exibitors were charged a $5 entrance fee, which entitled them to one season ticket. Charges for space ran from $2 for 10 square feet to $100 for 1,000 square feet.

An appeal was made for loan of historical electric apparatus, and for books to be displayed and afterward retained in the library of The Franklin Institute.

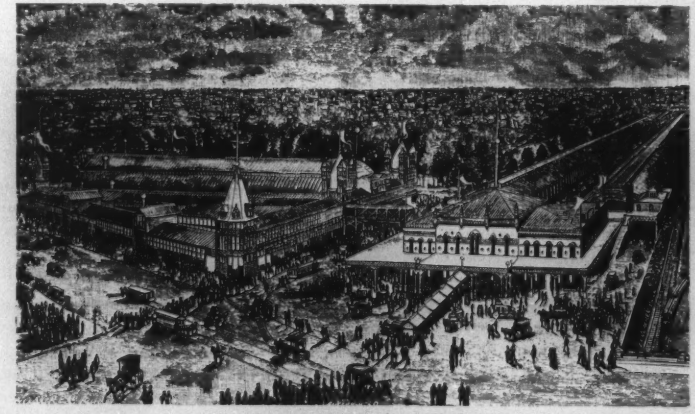
THE GRAND OPENING

On the morning of September 2, 1884, a crowd gathered in the depot. Precisely at noon, they were welcomed by Philadelphia's mayor, who then led them in procession across the bridge to the main Exhibition building. In the inaugural ceremonies that followed, President William P. Tatham of The Franklin Institute expressed the excitement of the occasion in these words, "The Electrical World of the United States is here fully represented; nay, it is here en masse!" Then the governor of Pennsylvania declared open the International Electrical Exhibition.

"Machinery was set in motion, the great central fountain spouted up, and the air was filled with the sound of innumerable electric bells and the peal of the electric organ."[1] The hall was brilliant with arc lights strung along each of the arches and incandescent lamps "strung everywhere." Fig. 3 shows an interior view of the main floor.

DISPLAYS OF U.S. ORIGIN

The Exhibition was "international" in name only.



Courtesy of Electrical World

Fig. 2. The electrical exhibition buildings.

Only 2% of the 2,500 exhibits were from foreign countries.

Electric light, telephone, and telegraph companies displayed their systems, complete with accessories. Manufacturers displayed competing designs of their equipment. There were original and improved models of important and minor inventions, often demonstrated by the inventor himself. Edison was there with 2,000 white and colored incandescent lamps wound spirally on a 20-foot-high cone. There were unknown inventors vying for attention, hoping to find recognition and financial backing.

A small edition of the electric arc-light tower, familiar to western cities but little known in the eastern states, attracted admiring attention.

An electric railway on a 400-foot track, which was to have been in full operation throughout the Exhibition, finally took its trial trip on closing day. Powered by a 8-hp dynamo, it carried a group of dignitaries up 32nd St. from Lancaster to Powellton Ave. at 8 miles per hour, attaining a brisk 20 miles per hour on the slightly downhill return trip.

ATTENDANCE

During its 5½ weeks, the Exhibition attracted 285,000 visitors. The largest single day's attendance of 17,000 occurred, by coincidence, on the first day of AIEE's meeting. Meetings of five associations held in conjunction with the Exhibition contributed immeasurably to over-all attendance. Visitors ranged from great scientists of the day to school children, who for 15¢ were admitted to lectures on electricity and its uses. (The exhibitors, it was reported afterward, would have been pleased with the presence of fewer "sweet girl graduates" and "rivals of Peck's bad boy."[2])

THE EXHIBITION ENDS

The Electrical Exhibition closed at midnight on October 11, and was, as *Electrical World* had predicted, "the grandest of the kind the world ever saw." The Franklin Institute, which had expected no profit, realized approximately $10,000, and acquired over 2,000 scientific volumes for its library. Moreover, it had contributed a well-placed stepping stone to the nation's path of progress.

AN ENGLISHMAN REPORTS

Sir William Preece, AIEE's first Honorary Member and electrician of the British Telegraph Department, toured Canada and the United States in 1884, attending several association meetings, including AIEE, as well as the Exhibition. In a report of his trip,[3] he stated that the American electrical goods made a "fine" exhibition; one that no other single nation could bring together.

Sir William was amused at our inclination to adopt electrical contrivances for "all sorts of purposes." (We still do. In September 1959, a new electric-powered fish scaler was demonstrated at the Coliseum in New York City; purpose: to free fishermen from after-sport drudgery!)

TELEPHONE—U.S. VS U.K.

In 1884, there were only 11,000 telephones in use in the United Kingdom as compared to 148,000 in the United States. Sir William had no difficulty explaining why; it was because of our sweltering heat. With temperatures from 90 to 100 degrees, he pointed out, you exist in a sort of Turkish bath, and want to be saved every possible reason for leaving your office. The telephone enables you to loll back in your chair with your feet on your desk and a bottle of ice water nearby, and, thus, to carry on business transactions with some degree of comfort.

Sir William also pointed out that in England, an errand boy was available at half a crown a week, compared with 12 shillings to 15 shillings for similar service in the United States. Thus, he reasoned, the telephone permitted transaction of business at less cost, as well as in greater comfort.

Preece decried the unsightly overhead wires in this country, but considered as hopeless the cause of the minority who wished to have them placed underground. To quote him directly, "It is said that the Town Council of Philadelphia have issued most stringent orders that on the 1st January next, men with axes and tools are to start out and cut down every pole in the city. It is all very well to threaten; but my impression is that any member of the Town Council or any individual of Philadelphia who attempts to do such a thing will be lynched by the first telephone subscriber he meets."

NATIONAL CONFERENCE OF ELECTRICIANS

A National Conference of Electricians was held in Philadelphia, September 8-13, 1884. The conference, attended by 100 European and American experts, was conducted by the United States Electrical Commission under a Congressional appropriation of $25,000.

In his opening address as president of the commission and the conference, Prof. Henry A. Rowland of Johns Hopkins stated, "Let not . . . the devotee of pure science despise practical science, nor the inventor look upon the scientific discoverer as a mere visionary person. They are both necessary to the world's progress and . . . to each other."

Sir William Thomson (later Lord Kelvin), vice-president of the conference, stressed the importance of an international system of electricial measurements and international standards.

A resolution was adopted recommending that Congress establish a National Bureau of Standards. Congress complied—17 years later!

BRITISH ASSOCIATION MEETS AT MONTREAL

The British Association for the Advancement of Science (BAAS) held its 54th annual meeting at Montreal, Que., Canada, August 28-September 3, 1884. Of its 1,773 members, 800 crossed the ocean to attend. Members of the sister American Association for the Advancement of Science (AAAS) were invited guests. Of 327 papers presented, 40 were authored by Americans.

One of these singled out as "valuable and interesting" was titled "On the Customs and Language of the Iroquois." The author, Mrs. Erminnie A. Smith, had been adopted as a sister by one of the chiefs of the Tuscarora tribe The following week, Mrs. Smith was elected secretary of a section of the AAAS, the first woman to hold office in the association.

Five of the evening lectures were selected for printing at full length, two of them by Americans: Prof. Thurston of Stevens Institute who spoke on the steam engine, and Prof. Asa Gray of Harvard who discussed North American vegetation.

At the conclusion of the BAAS meeting, 300 of its members traveled by special train to Philadelphia, to attend the meeting of the AAAS, and to inspect the Exhibition.

THE AAAS MEETS IN PHILADELPHIA

THE ACADEMY OF MUSIC in Philadelphia was the scene of the 33rd meeting of the AAAS, September 4-11, 1884. The appeal of the Exhibition and the assemblage of visiting BAAS members combined to make this the association's largest meeting, with nearly 1,300 in attendance. 200 papers were announced, but over 300 were presented.

Alexander Graham Bell gave a paper entitled "The Evolution of a Race of Deaf Mutes in America." Among other topics were astronomy, musical sand, and the origin of life. An English visitor, Prof. J. B. Martin, spoke on "The Future of the United States!"

An International Electrical Congress was advocated in a petition presented in Philadelphia as it had been at Montreal, but organization of such a group was regarded as "improbable."

Courtesy of Electrical World

Fig. 3. Interior of main exhibition building.

ENTER THE AIEE

THAT THE ELECTRICAL EXHIBITION was a motivating factor in the formation of AIEE is clearly indicated in the "Call" to organization circulated for signatures in April 1884 by our founder, Nathaniel S. Keith. Electrical experts from many countries were expected to be drawn to the Exhibition in Philadelphia. "It would be a lasting disgrace," wrote Keith, "if no American . . . society were in existence to greet them."[4]

In accordance with action taken at the first meeting of the AIEE Board of Directors (then called the Council) on May 20, 1884, Secretary Keith went to Philadelphia to secure accommodations for AIEE at the Exhibition. The Franklin Institute generously offered the use of rooms in one of the towers of the main building, which Keith accepted.

At a meeting of AIEE's Executive and Finance Committees on August 18, Secretary Keith was authorized to furnish one of the rooms as AIEE headquarters, and to be present during the Exhibition as the Institute's official representative. For personal and staff expenses, he was voted the sum of $50 per week.

COMMUNIQUÉ FROM PHILADELPHIA

DURING THE LAST WEEK in September 1884, Secretary Keith issued from the Exhibition a notice[5] which read in part:

> "The second meeting of the Institute will be held in Philadelphia on Tuesday, Wednesday and Thursday, the 7th, 8th and 9th of October, 1884. . . . A supplemental circular will be mailed to the members in a few days, giving further announcements and the terms, etc., of railroad, hotel, exhibition and other accommodations, the hall of meeting, etc. . . . Immediate notice should be made to the secretary of intention to read papers at this meeting . . . so that they may be timed as to reading and duly announced. . . ."

It is regrettable that we do not have a copy of the "supplemental circular," nor of the program of the meeting. Such meagre reports as are available are in conflict as to the duration of the meeting. The historical preface to the first volume of our *Transactions*, written several years later, states that "On October 7 and 8 a meeting was held. . . ." However, the text of Secretary Keith's notice and the press account[6] of the meeting by a reporter who claimed to have been present, indicates that it lasted 3 days.

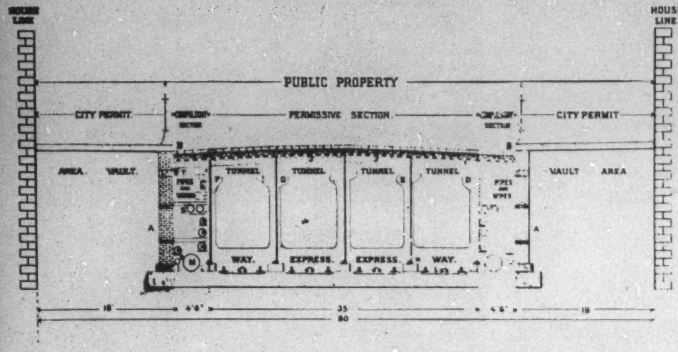


Fig. 4. Cross-section of the "Scientific City Street" as applied to Broadway, New York City.

line entrances on side streets, and platforms were to employ a limited part of the vault area. Pipes and wires would be specially arranged at stations. Galleries could be entered by doors from the stations along the line, avoiding "the incessant tearing up of the pavement which constantly destroys the surface of the roadway at present." Little did the author know that 75 years later, harried motorists would still be uttering the same complaint!

Col. Hazard's paper was written fully 20 years before New York's first electric subway was placed in operation. It is indeed regrettable that the colonel's systematic assignment of space was not followed.

THE MEETING IS HELD

On the morning of October 7, AIEE members met in Parlor C of the Continental Hotel, which stood on the present site of the Benjamin Franklin Hotel. In the afternoon, the members as a group inspected the Exhibition. On October 8 and 9, meetings were held in the Institute rooms of the Exhibition building.

In all, 11 papers were presented and discussed. Among subjects treated were insulated wire, electroplating, and the United States Patent Office. Three papers dealt with telegraphy, two with magnetic fields of dynamos. Ten of the papers are included in our *Transactions*. The 11th was called "Exploring the Field of the Dynamo-Electric Machine." Unfortunately, the author, C. O. Mailloux, was prevented by illness from preparing his paper for publication. Mailloux, then a consulting engineer, and electrical expert for *Electrical World*, was instrumental in starting the Engineering Societies Library in 1903, and became AIEE President in 1913-14.

Two papers from our first technical meeting seem now to have been of particular significance.

A BROADWAY SUBWAY PROPOSED

"The Scientific City Street" was presented by Rowland R. Hazard, president of the Gramme Company and AIEE's initial treasurer. Col. Hazard was vigorously protesting the proposed introduction of a horse- or cable-type surface railroad to New York City's Broadway, which he had regarded as the most noted and handsomest street in America.

Hazard's AIEE paper described his own alternate plan, which utilized an underground electric railway. Included was a colored cross-section drawing (Fig. 4) alloting space for two local and two express subway tracks, a vault area under sidewalks, and galleries between vaults and subways to house pipes and wires for water main, water distribution, sewer, gas main, gas distribution, street gas, steam pipes, and pneumatic tubes.

Subway stations were to be approached from curb

ANOTHER EDISON "FIRST"

The other paper of special interest was written by a famous Philadelphia scientist, Edwin J. Houston, and

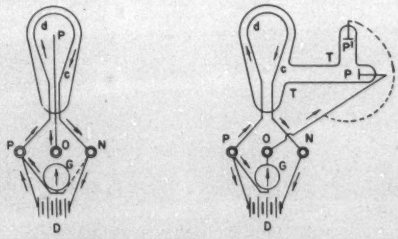


Fig. 5. Experimental incandescent lamps used in discovery of "Edison Effect," 1883. (Paper no. 1, Philadelphia, Pa., Oct. 7, 1884.)

was the first paper to be presented. Head of the natural philosophy department of Central High School, Prof. Houston was also chief engineer of the Exhibition, and author of a series of primers on electricity and magnetism available there. He later served two terms as AIEE President, 1893-94 and 1894-95.

The title of Houston's paper, "Notes on Phenomena of Incandescent Lamps," gives no indication of the importance of the subject treated.

While investigating the blackening of his lamps in 1883, Edison inserted a wire between the legs of the filament and brought out a third terminal. He found that if the third wire were connected through a galvanometer to the positive leg of the filament, a current flowed between the filament and the wire, as illustrated in Fig. 5. Houston's paper discussed a theory for this "Edison Effect."

Actually, Edison had discovered thermionic emission, a discovery which was to usher in the fourth era in the history of electrical development: electronics. Edison obtained the first patent in that field in 1884. It is interesting to note that 20 years elapsed before further development in electronics took place.

CONCLUSION

SURELY, great strides will have been recorded in Institute annals by October 1984, when the centennial celebration of AIEE's first technical meeting will be held in Philadelphia. If the progress potential of the next 25 years is realized, the accomplishments of the past 75 years will seem small by comparison.

In 1884, in an editorial applauding Edison's announced intention of returning to original inventing, *Electrical World* used these words, attributed to Archbishop Richard Whately, "the larger the circle of light, the greater the darkness revealed beyond."

That circle of light is now to be gradually widened beyond the earth to illuminate our solar system. Since our solar system is but part of one of an unknown number of galaxies, the encompassing area of darkness will grow beyond imagination. And as the darkness grows, so too will grow the need for men whose forte is electricity. Of this we may be sure: without electrical science and engineering, there could be no space age.

REFERENCES

1. The Annual Encyclopaedia. D. Appleton & Co., New York, N. Y., vol. IX, 1884, p. 304.
2. Editorial, "The Close of the Exhibition." *Electrical World*, New York, N. Y., vol. IV, no. 15, Oct. 11, 1884, p. 132.
3. A Visit to Canada and the United States in the Year 1884, William Preece. *Journal of the Society of Telegraph-Engineers and Electricians*, vol. XIII, 1884, pp. 570-92.
4. Historical Preface, AIEE *Transactions*, vol. 1, 1884, p. 1.
5. AIEE News Item. *Electrical World*, New York, N. Y., vol. IV, no. 13, Sept. 27, 1884, p. 111.
6. *Ibid.*, vol. IV, no. 15, Oct., 11, 1884, p. 129.

Computer on the Street

Approximately $3 million worth of high-powered electronic data-processing equipment is shown on the sidewalk waiting to be moved into the Wall Street offices of Bache and Company in New York City.

With more than 12 million Americans currently investing in the market, all of Wall Street faces the problem of handling a growing volume of information. The new IBM *705 Model III* computer will enable Bache and Company to complete the paperwork on its average of 6,500 daily trades in 12 hours—half the previous time.

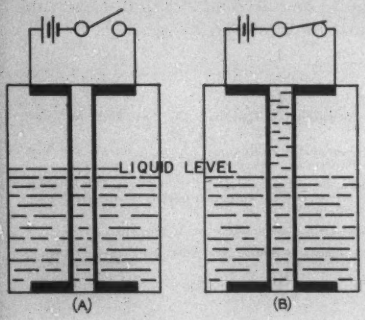
Scheduled to go into operation shortly, the *705 Model III* at Bache will be the fastest data-processing system in the financial district—capable of handling 780 trades a minute. In addition to processing these purchases and sales, the system will maintain stock records, perform margin and bookkeeping operations, and prepare monthly customer statements. The data-processing system also will enable Bache and Company to speed preparation of customer portfolio analyses.

The *705 Model III*, largest commercially available computing system, can add a column of 11,400 5-digit figures in a second and make 45,400 logical decisions in a second. It is the third generation of electronic data-processing equipment to be used at Bache. A small scale IBM *604* electronic calculating punch, installed in 1950, was the first in this line. Three years ago the firm began using a stored-program computer when it installed an IBM *650*, the world's most widely-used electronic data processing system. The new *705 Model III* can store 40,000 digits of information internally and millions more on magnetic tape.

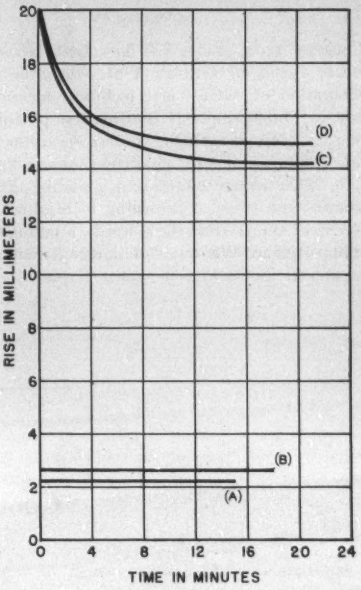
Liquid Dielectrics in an Electric Field

W. H. MIDDENDORF
MEMBER AIEE

G. H. BROWN



◄ Fig. 1. Cell for cross-field displacement.



► Fig. 2. Cross-field displacement vs. time: (a) Benzene, chromel electrodes 3/32 inch apart, in air, 5,000 volts applied; (b) Bromobenzene, stainless steel electrodes 3/32 inch apart, in vacuum, 4,000 volts applied; (c) Nitrobenzene, stainless steel electrodes 3/32 inch apart, in air, 3,000 volts applied; (d) same except chromel.

STUDIES of pure liquid dielectrics under the influence of relatively intense electric fields reveal a phenomenon of mass transfer. Two variations of liquid displacement are possible. One is called cross-field displacement. It may be produced by partially immersing two rod-like electrodes in a liquid dielectric. The other is called co-field displacement. This type of mass transfer may be produced by immersing energized electrodes made of parallel screens in the dielectric liquid. Fig. 1 shows a simple cell for cross-field displacement.

The mechanism by which the liquid is displaced is not known with certainty. Some insight into the phenomenon can be established from the quantitative data presented, as well as by certain qualitative observations made during these studies.

The curves (Fig. 2) of cross-field displacement vs. time obtained for nitrobenzene, bromobenzene, and benzene reveal two types of variations. They are: (1) displacement which does not vary with time, and (2) displacement that decreases approximately exponentially from an initial value to a lower, steady-state value.

It has been found that the liquids for which the second type of variation is appropriate have a current time characteristic which reveals a decreasing ionic concentration during the period immediately after the voltage is applied. For those liquids whose displacement does not vary with time, however, it has been found that the current may be ascribed to electron movement.

There are several properties of the liquid state which provide a basis for explaining the liquid displacement. One possible source of mass transfer is that of ions which are present in the system. Ions act as centers around which polar molecules cluster and the cluster thus formed will be drawn to one of the electrodes depending upon the charge of the ion in the cluster.

Another contribution to the liquid displacement may be from uncharged clusters or swarms of molecules within the liquid. The presence of associated molecules (cybotactic groups) in all liquids was proposed by G. W. Stewart (*The Physical Review*, vol. 30, July 1927, pp. 323-44) some years ago. These cybotactic groups would be expected to have a higher dielectric constant than the main bulk of the liquid. Such groups move into the region of highest field intensity. The increase in energy density near the electrodes, however, tends to break the cybotactic groups. Then, since the number of associations for a given liquid depends primarily on thermodynamic considerations, new groups will form in the main body of the liquid to move toward the electrodes.

In summary, mass transfer of pure dielectric liquids in high electric field is the result of either or both of two mechanisms. One depends upon the presence of ions within the liquid; the other depends upon the presences of cybotactic groups within the liquid. By designing equipment properly, one can use both of these mechanisms to cause liquid dielectrics to rise or flow.

Digest of paper 58-880, recommended by the AIEE Dielectrics Committee for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Published in AIEE *Transactions*, pt. III *(Power Apparatus and Systems)*, vol. 77, Oct. 1958, pp. 795-99.

W. H. Middendorf and G. H. Brown are with the University of Cincinnati, Cincinnati, Ohio.

Load Characteristics of a Smelting Furnace

GEORGE GRANT III
MEMBER AIEE

SUBMERGED arc furnaces have been in commercial operation for more than 50 years. However, the literature tells little about what they require from the supplier of the electric energy or what effects they have on the supply system. Information follows on the electrical performance of such a furnace.

The process of smelting silicon consists of heating silica (silicon dioxide) with carbon. The carbon combines with the oxygen from the rock and leaves the silicon in a molten state at the bottom of the furnace. It is tappped at regular intervals. The mix of silica and carbon is fed in around the electrodes and produces a conducting path between electrodes. The conductivity of this path consists of a multitude of contacts which continually change as the mix moves toward the bottom of the furnace and as the reduction process proceeds. Electric energy also goes from the electrodes through arcs to the metal in the bottom of the hearth. As a result, several factors affect the electric load in the furnace, with the multiple paths through the mix continually tending to make the load unsteady. By proper control of the mix and by the use of the proper voltage, the variation in conductivity through the multiple paths can be made to cancel one another and produce an over-all conductivity that is relatively steady.

The circuit supplying the power to the furnace electrodes determines the power factor. The reactance of the furnace transformer is the major factor here. In Fig. 1, the megawatts and power factor of the load are shown as functions of the megavolt-ampere demand. The relationship is shown for the four voltages found to work best in this installation. These show that it is best to operate at as high a voltage as possible because of the higher power and power factor for a given volt-ampere demand. This also results in steadier load.

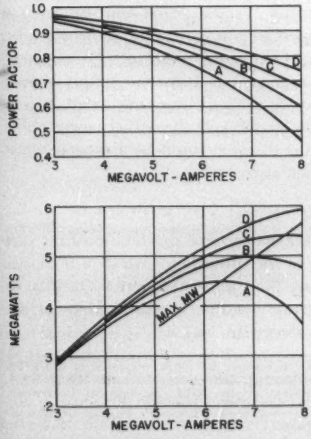


Fig. 1. Furnace characteristic: transformer 6 mva, 6.7% reactance; high voltage 13.8 kv 60 cps; low voltage A-100, B-105, C-110, D-115.

Desirable scheduling of operations calls for 24-hour operation at 6 mva. In practice, an operating time factor of more than 90% is maintained. Fig. 2 shows the momentary and 15-minute demand charts recorded when the operation was considered to be good. A period including a shutdown was chosen to show that no inrush currents are experienced. Further, these charts indicate that a load of 6 mva is dropped and again picked up with no tapering off or gradual increase. Of course, shutdowns are not desirable, but if they last less than 8 hours, they do not cause insurmountable problems. Under load, the power factor ranges from 0.80 to 0.87 and the demand has approximately 10% spread. No flicker problem exists under these conditions.

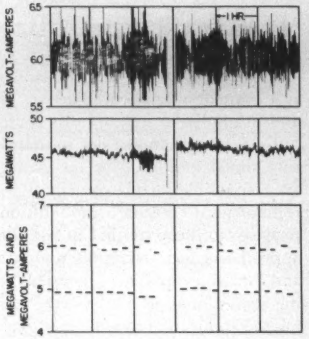


Fig. 2. Momentary and 15-minute load charts; good operation.

When poor operating conditions are occasionally encountered, the thermal values remain substantially the same. The spread in momentary values increases to 30% and slight flicker is sometimes produced. Infrequently, downright bad operation develops and gives thermal demand spreads up to 40% with momentary demand spreads greater than 60% and severe flicker.

This 6 mva at 0.83 power factor load is normally steady. Its prime requirement is to go on and off the line without creating a disturbance on the system. However, it may occasionally cause heavy load swings and a flicker problem.

Digest of paper 58-1259, "Load Characteristics of a Submerged Arc Silicon Smelting Furnace," recommended by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1959.

George Grant III is with the Dow Corning Corporation, Midland, Mich.

Peripheral Professional Problems of Engineering Management

C. F. SAVAGE
FELLOW AIEE

The manager of engineering has the responsibility for assuring optimum utilization of all facilities. The concept of peripheral professional problems points out the many areas of interest to which the manager's attention must be directed.

MANY ENGINEERING ARTICLES and papers have as an introduction a statement relating to the pace of technological growth. "Explosive" is a commonly applied adjective. Numerous references and examples to support this contention are familiar, but not so well known nor so sharply oriented is literature aimed specifically at the managers who direct and are responsible for the contributions evolving from this technological "fission" and "fusion." This discussion proposes to illustrate that in addition to absorbing and appreciating new technical understanding, knowledge, and lore as it rapidly is generated, the engineers managing professional people have the responsibility of assuring the application in a manner that results in optimum utilization—in its broadest sense—of all facilities.

To do this, the manager must use techniques that extend far beyond those found in the discipline of engineering. In fact, the engineering executive is "surrounded" by a multiplicity of motivating needs for activity to which he may or may not be fully acclimated. Hence, this concept of the peripheral professional problems of the managers of engineering will direct attention to those areas of interest. As problems are synonymous with opportunity, proper programs will result in a professional climate consonant with the objective of the business.

ENGINEERING AND OTHER DISCIPLINES

ENGINEERING is one of some 23 easily identified professions.[1] Engineering is the custodian of a particular branch of knowledge and it follows that this pattern is similar to many other professions within specific disciplines. The extent to which these fields of knowledge are "pure" and to which they overlap in the professions is of interest at this point.

Fig. 1 illustrates one way of indicating the overlapping that may occur between more than one discipline. Engineering, as shown, is concerned directly with knowledge in the fields of (1) mathematics, (2) science, (3) materials, and (4) the activity of innovation. However, the practice of engineering, i.e., the applying of the knowledge of a profession, necessarily draws upon the knowledge in fields which are classified as belonging to other disciplines.

The disciplines of political science, economics, psychology, and managing are those in which the managers of engineers must perforce be interested. From the area of political science comes knowledge of community relationships that is fundamental to motivating and integrating groups. Industrial and consulting firms and activities only indirectly connected with business require application of this knowledge in many ways. Motivation of the business team, systems engineering, and operation of technical societies are examples.

Often managers wish for more knowledge on the subject of economics. The results of different kinds of work involving many objectives are measured in terms of economic impact. Certainly, knowledge of economics within the boundaries of good legal practice and within the techniques of accounting is essential to the manager of engineering, for the purpose of analyzing and controlling the effort of his total organization.

The profession of psychology contributes, through industrial psychology, the knowledge and understanding required to design programs that are conducive to the development of the individual. Within either the framework of self-development by the individual engineer or in the area of recruiting, the importance of this overlap is apparent.

This presentation of the discipline of engineering management is grossly oversimplified. But, by definition, the manager of engineering is doing the work of the professional manager—planning, organizing, integrating, and measuring. To the degree that proficiency and skill are attained in applying this knowledge, he will gain leadership for his organization.

It is the intent of Fig. 1 to illustrate simply that a manager of engineering work utilizes knowledge outside the discipline of engineering. If the subject were other than engineering, the diagram could be arranged interchangeably for other disciplines.

PERIPHERAL CONCEPT

A RATHER SIMPLE EXPANSION of the relationships just discussed, in terms of the subjects for which a manager of engineering must plan and take action, results in the geometrically represented peripheral concept of the responsibilities, as shown in Fig. 2.

Essentially full text of District paper DP59-678, presented at the AIEE Middle Eastern District Meeting, Baltimore, Md., May 19-21, 1959. Recommended for publication by the AIEE Management Committee.

C. F. Savage is with the General Electric Company, Engineering Personnel Services, New York, N. Y.

The application of engineering work results in a design of a product or in a service rendered to a customer. Because of the diversity in kinds of service, the examples of the subjects are focused primarily on product engineering, but they apply to all engineering with only variation in degree.

Clearly, the primary effort of the manager of engineering will be to draw upon the knowledge from the profession of managing to lead his organization in the optimum discharge of its responsibilities. This requires of him a delicate and sensitive sense of balancing—a recognition of the proper mix and ability to proportion his managerial attention to fit the dynamics of the engineering climate. By definition, the periphery is the "outward bounds of a thing as distinguished from its internal regions or center." Thus, Fig. 2 diagrams the various work elements which, in the aggregate or total, make up the work which the manager of engineering must manage. It is useless to argue which of these work elements is most important, since this leads to the frustration of the "which is the most important—the heart or lung" type of discussion. The important point is that the manager of engineering recognize as a minimum all of the elements of work as shown in Fig. 2, even though, for the purposes of illustration, these are arranged as shown in this static diagram. It is probable that this is a characteristic arrangement, although, because of dynamics, any work element may be at any one time closer to the center of focus.

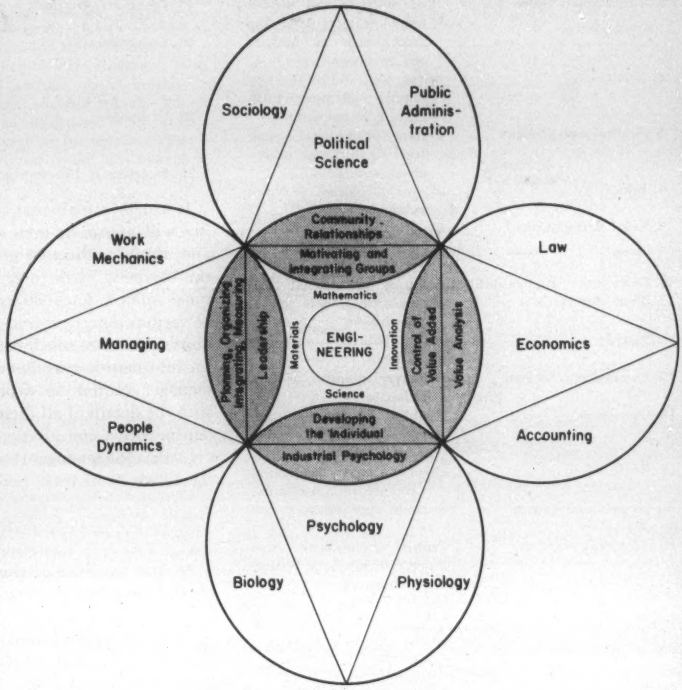


Fig. 1. Engineering and other disciplines.

The inner circle of characteristics indicates that the product must have:[2]

1. Suitable cost
2. Technical excellence
3. Attractive appearance
4. Mechanical unity
5. Availability at the proper time

The next "circle" of subjects, "profit," "innovation," etc., is that in which the manager must be interested (1) to assure continuity of the business, (2) to co-operate with other functions of the business, or (3) to provide a working climate for competent personnel who have the creative spark required today. The knowledge necessary requires an integration of that from several professions.

The subjects diagramed in the peripheral circle are greater in number, because the activities support those listed in the inner ring just noted. For example, recruiting activities are a concern of the manager, since these supply the technical competence in terms of manpower required to produce the design.

PROFESSIONAL CLIMATE

THE REMAINING SUBJECTS, the activities connected with them, and presupposed success in reaching the desired objectives for each are of particular interest because, in the aggregate, these are the subjects that produce a professional climate.

Subject	*Comment*
1. Compensation	Make commensurate with contribution
2. Benefits	Provide with character suitable for professionals
3. Salary Communication	Satisfy the "desire to know" adequately
4. Physical Facilities	Design for character of work and professional people

5. Educational Opportunities	Plan multiple and flexible forms to meet long and short needs of business and engineers
6. Unions	Stress that collective bargaining and professionalism are incompatible
7. Professional Societies	Permit professional engineers to discharge professional responsibilities
8. Ethics	Adapt to specific activities and make known
9. Legal Recognition	Supply continuous activity for maintenance of standards
10. Community Responsibilities	Assist on professional basis
11. Trade Secrets	Maintain awareness of responsibilities
12. Patents	Assure policies proper and equitable
13. Employment Security	Define relationship of professionals
14. Orientation	Establish program to improve initial effectiveness and build loyalty
15. Registration	Observe legal boundaries and improve standards
16. Honors and Awards	Promote opportunity to obtain
17. Technical Societies	Permit professional engineers to discharge technical obligation
18. Corporate Practice	Observe legal boundaries and improve standards
19. Communication	Make known policies on *all* subjects that pertain to business objectives and professional climate
20. Utilization	Assist professionals to attain optimum opportunity to contribute
21. Professional Development	Provide realistic programs

It can be anticipated that any manager of engineering will approach these peripheral subjects in extent and degree as dictated by his judgment of the needs of the business. There may be some bias because of personal interest. Each subject could be expanded in terms of various objectives and activities aimed to meet these objectives. Also, much information of a general nature for informative purposes could be supplied. In fact, the manager cannot be expected to be fully acquainted with the details of all these peripheral subjects and must depend upon consultations with specialists. Note, however, that the manager cannot delegate his responsibility for activities in these peripheral areas.

TECHNICAL SOCIETIES

As ONE EXAMPLE of the expansion that can be done on the information for any and all of these subjects, it is appropriate that technical societies be explored briefly. These societies provide symbols of professional stature by means of their membership certificates, examples of which are shown in Fig. 3. Such certificates indicate continuous contributions. The manager should provide the opportunities for his professionals to contribute.

Contributions may be in the form of technical papers. Why publish? An outstanding statement in answer to this question was made by Dr. C. G. Suits of General Electric:

"For the professional man, scientific or otherwise, *recognition* by his professional associates and by the organizations in his field is generally at the head of his list of professional aspirations. (In this discussion I will be using the word "scientist" because their environmental considerations are somewhat more familiar to me, but I believe that what will be said applies with little change to engineers and other professional specialists.) Recognition by the scientific community heads the sci-

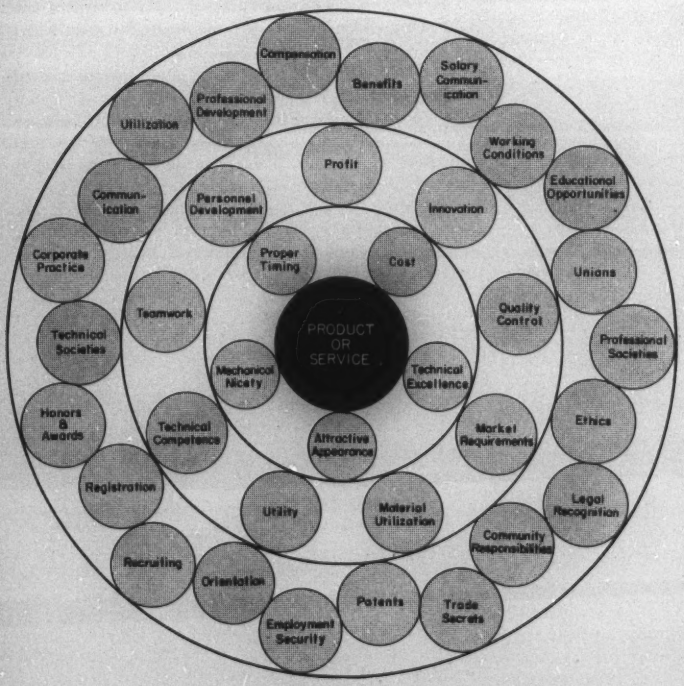


Fig. 2. Peripheral concept of an engineering manager's responsibilities.

entist's list of desired attainments not only for reasons involving the satisfaction of *identification* with his professional field, but also because there is a practical need for exposing one's work to *appraisal* and *evaluation* by other scientists.

"The professional and technical societies comprise, in aggregate, a 'supreme court' of informed scientific opinion. The verdict of this court concerning the importance of scientific work generally transcends the opinions of the author or the sponsors of the work. To be sure, the verdict may not be explicit nor prompt, but it generally is final and inescapable. It does what the author, because of his proximity to the work, usually cannot do—properly judge a new scientific result in relation to the work of others, to development in the whole field, and to important progress in related fields or fields that are competing in scientific interest with the author's field.

"The participation of a scientist as a contributor to the work of the technical societies also develops some important advantages for the sponsor. The sponsor of the research —industry, university, or government—shares in the recognition accorded the individual and is aided by the verdicts of the courts of scientific opinion. As a corollary benefit, it is doubtful whether any public relations activity—in the scientific community—equals the effectiveness of a policy that not only permits but indeed encourages the prompt publication of scientific work.

"Furthermore, the sponsor of research must remember that modern technical progress—including his own—is built on *prior work* by scientists the world over. A recognition by the sponsor of an obligation to contribute to the common pool of knowledge, upon which future progress will be built, can be justified on purely selfish grounds alone."

The manager will want to build professional attitudes in his men by making known these philosophies. And, to solidify the engineer's intent, information such as that outlined in the preceding section may be made available.

Many engineers utilize technical societies to obtain technical information and keep informed. F. J. Van Antwerpen noted:

"Recently, an International Conference on Scientific Information was held in Washington, D. C. This was under the auspices of the National Science Foundation, the National Academy of Sciences–National Research Council, and the American Documentation Institute. Among the problems discussed was how the scientist obtains information and how he learns of the work of others. A rather interesting group of facts was unearthed. Scientists in one study, on being asked how they learned of work crucial to their own, gave top priority to *casual conversation*, followed by *journal reading*. In another report, three tools stood out—regular scanning of journals, attendance at meetings and lectures, and face-to-face contacts with colleagues.

Among sources of ideas for current projects were listed, in order of importance, own previous work, colleagues, and reading of literature. The order may vary: the percentage of those who list one means above another--above conversation—may be higher in one study than another, but essentially it seems that meeting colleagues and talking with them, reading current literature, and attending meetings are the prime sources of ideas."

Technical societies are one of the basic elements in the engineer's striving for unity in the profession. Standards for industries are part of the work sponsored by societies.

These are some of the reasons why the manager will not only want his men to be active but why he will plan ahead for appropriate participations.

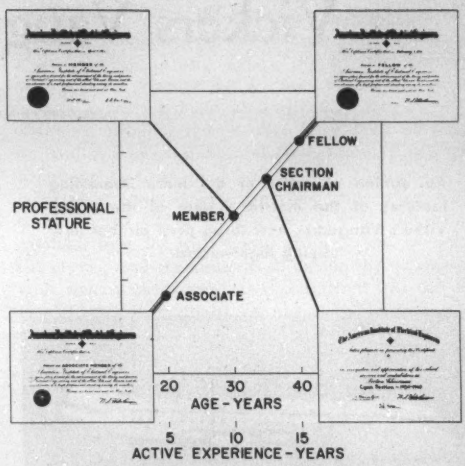


Fig. 3. AIEE membership certificates as status symbols.

PERIPHERAL CONCLUSIONS

THE MERE DISPLAY of a listing of the subjects within the sphere of activity of a manager of engineering may be helpful in orienting the work pattern. Many activities apply directly to producing a product or providing a service. The subjects as noted in the peripheral display provide a listing of those on which activity could be taken to improve or produce a professional climate conducive and, in some instances, necessary for more effective work intimate to the product. Much detail is available on these subjects for managers interested.

In summary, consideration of these peripheral subjects is urged

1. As a check list for determining the policy status of an engineering organization.
2. As a guide and check list of activities relating to a professional climate.
3. As an aid in determining measurement criteria for the operation performance.
4. As a potential method of feedback for improving the performance of the organization and the development of individuals.
5. As a check on legal position as related to the operation.

It may be that the peripheral subjects act as a bounding magnetic field in which the "plasma" of engineering contribution is maintained in an energy state of "fusion."

REFERENCES

1. Education for the Professions. U. S. Department of Health, Education and Welfare, Washington, D. C., 1955, p. 16.

2. Successful Product Design, I. F. Kinnard. *Machine Design*, Cleveland, Ohio, June 1953.

Vickers Vanguard Electrics

HARRY ZEFFERT
ASSOCIATE MEMBER AIEE

An outline of some of the more interesting features of the electric system of the British Vickers Vanguard, new turbo-prop airliner now being flight-tested.

Fig. 1. The Vickers Vanguard, second generation turbo-prop, carries up to 139 passengers in "economy" class and cruises at 425 mph.

THE Vickers Vanguard, second generation turbo-prop airliner, now in the flight-test stage, is due to enter service in 1960 (Fig. 1).

The Vickers Vanguard has a 28-volt d-c electric system with a considerable amount of frequency wild a-c available for deicing and other resistive loads. Primary generation comprises six variable-speed 50-kva self-exciting alternators giving a total system capacity of 300 kva, making the Vanguard system, in terms of power, one of the largest airborne electric installations in the world. The alternators are mounted on and driven by the engine gearboxes, two each being fitted to the outboard and one each to the inboard engines.

One alternator on each engine provides the power for its own propeller, spinner, and air intake electrical deicing, together with approximately 5-kva for galley and domestic heating loads. The d-c power is obtained from four 500-ampere silicon transformer rectifier units supplied from these alternators and fed to a common bus bar. This arrangment is illustrated schematically in Fig. 2.

The two additional alternators fitted one each to the outboard engines are used to supply the power for the windscreen and tail unit deicing. One alternator is used for both requirements with the other running on no-load; switching is provided such that the alternative alternator is available for use as and when required. It is intended that when used in airline service, an east-west switching routine will be established such that each alternator receives approximately the same utilization.

Six 24-volt, 25-ampere-hour batteries are fitted to meet the engine starting requirements and to provide an emergency source of d-c power. Constant frequency a-c is provided by three 3-kva rotary inverters, two of which are normally used with the third acting as a standby. In addition, a single 400-va inverter is fed directly from the battery bus bar to cater to the emergency radio loads in the event of all engine-main electric power failure. The complete power supply system is shown schematically in Fig. 3.

A departure from Vickers' normal practice with regard to main power systems is that the component parts have been designed and manufactured to Vickers-Armstrongs specifications, which have been put out to tender to the various component manufacturers concerned. A composite system has resulted but each item of equipment has been selected on technical merit and as a result, a very high degree of serviceability and operational performance is confidently expected. This policy has been adopted generally throughout the aircraft and the strictest possible technical control has been exerted on the component manufacturers; thus, many undesirable features encountered on previous equipments have been eliminated.

A novel feature of the main generation system is the provision of specially developed ground-flight adapters to facilitate testing and calibration of the various protection and control equipment without the necessity of running the engines. By this means, the complete system can be energized and operated from ground rigs for maintenance purposes without imposing the severe economic penalties associated with running engines for prolonged periods on the ground.

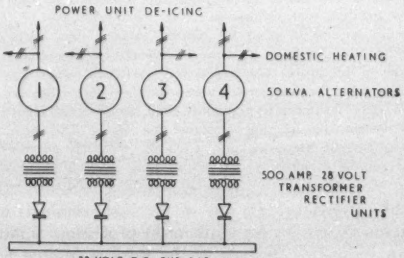


Fig. 2. Vanguard basic d-c system.

A special article recommended by the AIEE Air Transportation Committee.

Harry Zeffert is with Vickers-Armstrongs (Aircraft) Ltd., Weybridge, Surrey, England.

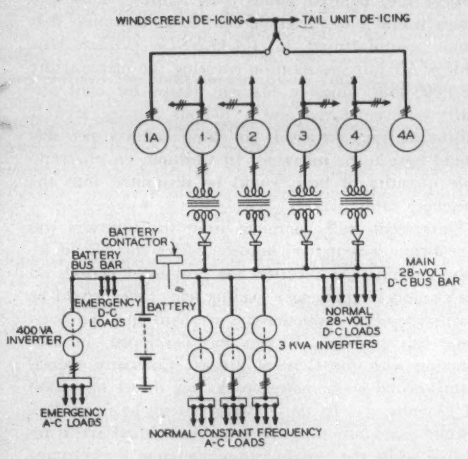


Fig. 3. Schematic of Vanguard a-c/d-c power supplies.

EMERGENCY SUPPLIES

THE ELECTRIC SYSTEM has been designed so that a-c and d-c power will always be available to supply essential services under any predictable circumstances. Conventional protection (over- and under-voltage, over- and under-frequency, etc.) is provided to cater to any faults which may occur in the four separate generation channels, effectively isolating individual alternators from the bus bar. In addition, a first stage emergency system has been incorporated such that the full d-c output from any one of two T.R.U.s (transformer rectifier units) can be fed directly onto a separate bus bar system for use in the event of main bus bar system faults. It is worth noting that in this direction, particular attention has been paid to ensure that adequate electrical and mechanical protection has been incorporated into the bus bar system so as to make this type of defect an extremely remote possibility.

In the first-stage emergency condition, the battery supply is switched to the first-stage emergency bus bar system to counteract the effect of d-c ripple which is a characteristic of any T.R.U. supply. The back-up capacity thus provided has not been considered usable in terms of aircraft loads, although this arrangement is obviously advantageous in that large fault currents are available for tripping protective devices (fuses and circuit-breakers) in the subdistribution circuits.

In the second-stage emergency condition (total electrical engine failure) sufficient electric power is available from the battery installation to sustain essential electric and electronic loads during the maximum glide time of the aircraft. It is considered that the degree of integrity designed into the main electric power supply system is such that total generation failure can only occur in the event of all-engine failure.

The emergency supply systems are illustrated schematically in Figs 4 and 5.

UTILIZATION

ELECTRICAL UTILIZATION on the Vanguard is extensive, particularly with regard to the use of frequency wild a-c for deicing and domestic resistive (heating) loads. Since engine bleeding imposes severe performance and economic penalties on turbo-prop engines, it was decided, in the initial design stages, to install variable-speed constant-voltage alternators of large capacity to provide the necessary power for power-plant and tail-unit deicing.

A 28-volt system was selected for d-c utilization on the basis of availability of airborne components, airline operators current ground equipment, and after a very careful study of environmental and operational factors.

The rotary inverters for constant frequency a-c utilization have been specially designed and manufactured for the Vanguard to Vickers-Armstrongs specifications and sufficient capacity is available to meet any foreseeable combination of electronic loads likely to be specified by any potential operator of this class of aircraft during its service life.

In each of the three types of power utilization,

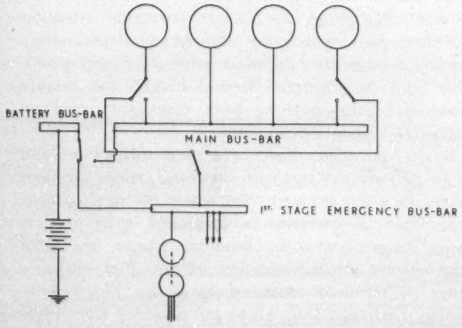


Fig. 4. *(left)* Schematic of Vanguard electric system's first-stage emergency condition—failed main bus bar.

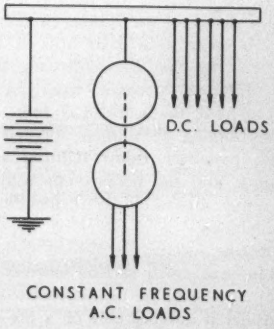


Fig. 5. *(Right)* Schematic of Vanguard electric system's second-stage emergency condition—total alternator-engine failure.

Fig. 6. Vanguard flight deck is laid out for operation by a 2-man crew. Flight instrumentation is fully duplicated for both pilots with engine instrumentation on the center panel. Situated to the rear of the throttles and high-pressure fuel cocks is a wide center pedestal panel incorporating all controls for radio communication and navigation equipment. Visible on the coaming are the four combined feathering fire-control handles.

healthy growth factors are available to meet future development. There is an exception to this rule, however, in that the 400-va emergency inverter has been tailored to meet the loads required in the all-engine-out case—the philosophy being that utilization should be kept to an absolute minimum to limit the weight of the inverter and associated control and distribution equipment. This philosophy is logical when one considers that it is most unlikely to be used (other than for functional checks) bearing in mind that the first-stage emergency system is provided.

In an article of this nature, it is not possible to include details of the various circuits and the manner in which power is actually utilized. It is perhaps worth mentioning that the experience gained in designing 50 different Viscount types for aircraft operators throughout the world has been used and in many cases, similar techniques adopted on the Vanguard. The passenger cabin lighting system is, however, unique and the background behind its introduction is rather interesting; consequently, a brief description is included.

As the interior furnishing design of the passenger cabin progressed, various schemes and proposals were evaluated. The use of incandescent filament lamps was considered unacceptable on a life expectancy basis; to achieve the required standard of lighting, some 600 lamps would have been needed. Even assuming that lamps manufactured to *VAAS.2(EL)* (Vickers-Armstrongs Aircraft specification covering the manufacture of 1,000-hour tungsten filament lamps for civil aircraft) were employed and a 10-hour average aircraft utilization rate achieved, six lamp failures per day would have to be tolerated! In addition, an unacceptable quantity of heat would be dissipated into the passenger cabin.

Fluorescent tubes supplied from the inverters was the obvious alternative; however, since this would involve running the inverters for prolonged periods on the ground for passenger loading, etc., there would be a corresponding reduction in overhaul life. To overcome this problem, Vickers has developed, in conjunction with the General Electric Company, special transistorized static power packs for direct operation off 28 volts, d-c. In the existing system, half the fluorescent tubes are supplied from individual static inverters, while the remainder operate from the constant frequency a-c supplies, the former giving a sufficient light level for cleaning, maintenance, and passenger loading purposes.

INSTALLATION

THE ENTIRE VANGUARD ELECTRIC INSTALLATION has been developed with a view to ease of maintenance, and throughout the various design stages, development engineers from British European Airways and Trans-Canada Airlines have been consulted on this aspect. This factor, together with the "double bubble" fuselage configuration giving a large volume available for freight and equipment bays) has resulted in an extremely acceptable installation from the point of view of the airline operator.

The main electric equipment bay is located under the main cabin floor, approximately half way along the fuselage. This compartment houses the control, protection, and distribution equipment for the electric system, the batteries, transformer rectifier units, and the rotary inverters. Access is provided for maintenance and servicing through a hatch in the bottom of the fuselage; in flight, access is gained through a hatch in the passenger cabin floor.

In view of the large amount of electric power distributed throughout the aircraft, particular attention has been paid to keeping the electric system above earth. Consequently, the main cable ducts and panels have been manufactured from Fiberglas and double studding techniques have been extensively used on heavy-duty feeder terminations.

Nyvin-type cables have been used throughout and ring-type terminal tags with dielectric crimps are used except in a few isolated cases where the development time scale of components precluded their use. A major improvement in terminal blocks has been achieved by the introduction of the Vickerstrip, a range of terminal blocks designed by Vickers-Armstrongs (Aircraft) Ltd. These are moulded from high-

temperature nylon and among the many advantages the block offers, weight, economy, high resistance to impact strength, and very good electrical properties are perhaps the most important. A color coding system has been incorporated to discriminate between different voltages (both potential and phases) and between one system and another. The different block sizes available make the Vickerstrip system extremely flexible, and very pleasing distribution panel layouts have been achieved on the Vanguard.

The Vanguard carries a 2-man crew and, in consequence, all instrumentations and controls are capable of operation from the pilots' positions. This has been a considerable design problem; however, the flight deck panel layout is extremely "clean" and presentation is simple and unambiguous. Throughout the design, the pilot's viewpoint has been very carefully studied and the Vanguard should prove to be a popular aircraft with flight crews when it enters airline service.

WIRING DIAGRAMS

Aircraft constructors' electrical design groups are primarily concerned with producing manufacturing drawings, which, although perfectly satisfactory for production purposes, have not always in the past fulfilled all the requirements of the airline operators' maintenance personnel. This has sometimes resulted in a considerable amount of redrawing by the operator. In order to overcome this problem, the wiring diagrams for the Vanguard have been drawn specifically for maintenance purposes and all data required exclusively for production has been excluded from the main drawing area in such a manner that it need not appear in the wiring diagram manual. In common with all data for Vanguard aircraft, wiring diagrams are presented in accordance with the requirements of A.T.A. (Air Transport Association of America) specifications *100*.

CONCLUSION

In an article as brief as this, it is impossible to do more than touch upon some of the most interesting features of the electric system. Electric systems as a whole come in for much unwarranted criticism but when one considers the large number of components used and the complexity of the associated circuitry, failures are bound to occur. On the Vanguard, the latest techniques have been employed, thousands of hours of laboratory testing have been carried out and the background of a million and a half Viscount flying hours has been used to the full, in an endeavor to reduce these failures to an absolute minimum. It is confidently expected that the Vanguard will enjoy a very high standard of electrical serviceability and prove a popular aircraft with the electrical engineers responsible for its maintenance.

Tabel I. Vickers Vanguard Suppliers of Main Items Used in Generation System

Component	Manufacturer	No. Per Aircraft	Leading Particulars
Alternator	Rotax	6	50 kva, 200 Volts, 3-phase variable frequency
T.R.U.	Ferranti	4	500 amperes at 28 Volts d-c
Inverter (Main)	Plessey	3	3 kva, 200 Volts, 3-phase 400 cps
Inverter (Emergency)	Plessey	1	400 va, 200 Volts, 3-phase 400 cps
Ground Flight Adaptor	B.T.H.	6	
Protection Devices	Rotax		Various protection units
Switchgear	B.T.H.		Various types of switchgear
Batteries	Peto and Radford	6	24 Volts, 25 amp-hr lead acid

Fig. 7. View inside electrics bay looking forward. Two of the four 28-volt, 500-ampere silicon transformer rectifier units may be seen in the right foreground. Behind them are the six 24-volt, 25 ampere-hour batteries.

Micro-Circuitry

Electronic miniaturization has taken a major step forward with the perfection of "Micro-Circuit" by International Resistance Company (IRC). Although Micro-Circuit was specifically designed to fill an urgent need in the missile-borne computer program of the Arma Division of American Bosch–Arma Corp., it will find many other important electronic applications.

Micro-Circuit development was directed particularly at the passive elements found in every electronic circuit: resistance, capacitance, and inductance. IRC has succeeded in making such components in molecular dimensions and essentially without weight. Components are now being made consistently with value tolerances of $\pm$ 5%.

The secret of the IRC Micro-Circuit is the deposition of exceedingly thin films of component material on a tiny substrate of glass, smaller than a postage stamp. Glass was chosen as the substrate because of its great structural strength and exceedingly smooth surface. Micro-Circuit is not simply a component wafer but is a fully integrated and operational electronic circuit.

The Internal Insulation of Generator Coils

D. A. FINDLAY
ASSOCIATE MEMBER AIEE

R. G. BREARLEY
ASSOCIATE MEMBER AIEE

C. C. LOUTTIT
ASSOCIATE MEMBER AIEE

Fig. 1. Generator *IM-4*; coil no. 30; position 3; 3.9% tip-up graded "terrible."

TO DATE, no satisfactory test has been found which will evaluate the condition of the internal insulation of generator coils and reliably detect deterioration such as illustrated in Fig. 1

Some 360 coils, removed from a 35,000-kva 13,200-volt waterwheel generator for repair of the protective tape, were power factor tested using commercially available equipment capable of measurements at voltages up to 12 kv. The power factor of each coil was measured and the 4- to 8-kv tip-up was calculated, this being the numerical difference between the power factors at 4 kv and 8 kv. This is a measure of the extent of the internal voids in a coil.

To correlate the value of tip-up with the condition of the internal insulation, 62 coils were dissected and graded into four groups—"acceptable," "poor," "bad," and "terrible." "Bad" and "terrible" coils were declared unfit for further service; Fig. 1 is an example of a "terrible" coil.

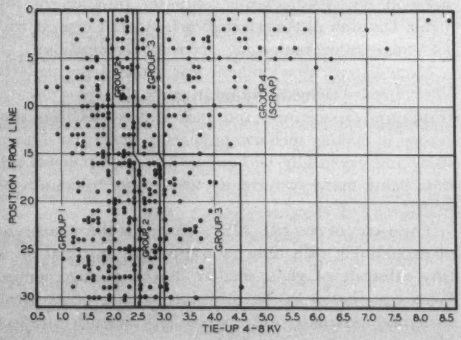


Fig. 2. Generator *IM-4*—position, tip-up, and grouping of complete winding.

As dissection progressed, it became apparent that electrical position of the coil in the winding was a significant factor. Plotting the power factor test results on a basis of electrical position vs. tip-up, and indicating the quality of a coil by a letter, it was apparent that "bad" and "terrible" coils were limited to those having tip-ups over 3% and formerly located in electrical positions at which the operating voltage was over 4,000 volts to ground.

Based on the foregoing facts, the coils were divided into four groups, as follows: group 1 or line-end coils (Fig. 2), no restriction as to their use; group 2 or mid-parallel coils, restricted to operation at 5,000 volts or lower; group 3 or neutral-end coils, restricted to operation at 2,500 volts or lower.

Correlation with other coils from duplicate windings indicates this technique may be applied to all coils built to this specification regardless of age. Further work has to be done to determine whether it can be extended to coils of different insulation systems.

Conclusions are:

1. Through dissection and examination of a number of coils, a method of evaluating the internal insulation has been developed based on individual coil power factor tests analyzed with respect to the former electrical position in the winding.

2. The d-c breakdown prediction and dielectric discharge tests failed to indicate that over 10% of the coils in generator *IM-4* had severely deteriorated internal insulation.

3. It is concluded that the ionization probe test applied to a winding in a stator does not effectively assess the internal deterioration, since no more than 10% of the "bad" and "terrible" coils in generator *IM-4* were located.

4. Since no disintegration of the internal insulation was found in the neutral half of the winding, corona attack, not heat or vibration, must be the essential factor causing the destruction of the insulation in the line-end coils.

5. Power factor testing is nondestructive and the analysis provides a qualitative picture of the coils as a group. Therefore, fewer satisfactory coils are destroyed and more defective coils eliminated than by the application of high-potential turn-to-turn and ground tests.

Digest of paper 59-25, "Evaluation of the Internal Insulation of Generator Coils Based on Power Factor Measurements," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Published in AIEE *Power Apparatus and Systems*, June 1959, pp. 268-79.

D. A. Findlay is with Saguenay Power Co., Ltd., Isle Maligne, Que., Canada. R. G. Brearley, and C. C. Louttit are with the Aluminum Company of Canada, Ltd., Shipshaw, Que., Canada.

Improved Standardization Procedure as Developed for Lightning Arresters

G. F. LINCKS
FELLOW AIEE

A change in procedure in which all interested parties have an equal opportunity to propose changes to ASA C62. This will result in one American Standard on Lighting Arresters instead of two or more separate standards that qu.te often conflict in overlapping areas.

TO BE EFFECTIVE, standards must have a wide, voluntary acceptance by the whole industry involved with the particular product. To do this, standards must represent the best thinking of the whole industry on the system needs and practices and on design advancements.

Standards must be current at all times in an industry developing as rapidly as is the electrical industry.

In most cases, present practices in preparing standards involve duplication or triplication of effort and, thus, become prohibitive in cost with the danger of limiting participation. Any attempt to curtail costs except by improving the efficiency of the operation can be disastrous to the universal acceptance of standards.

The channeling of areas of responsibility for standardization to specific organizations under existing standardization practices, such as "tests" to AIEE and "steps of rating" and "dimensions" to EEI (Edison Electric Institute) and NEMA (National Electrical Manufacturers Association), may not result in securing universal acceptance of the final American Standard. Naturally all interested parties wish to participate in the over-all problems. Also, the best thinking of all should be used in preparing and maintaining current all parts of the standards. Thus, it is desirable to open the door for full participation of all interested parties by suggesting and approving changes in all phases of the standards through the procedures of the American Standards Association (ASA).

A glance at the history leading to the recent issuing of the American Standard *C62.1–1957* for lightning arresters[1,2] will indicate that the procedure bore a close resemblance to present standardizing practices for most products in the electrical industry. The standard is in a field involving relatively rapidly changing system needs and practices, and design advancements to meet these changes. Prior to the issuance of the new standard, the American Standard *C62.1–1954* for lightning arresters was hopelessly out of date. The AIEE Standard 28, "Report on Lightning Arresters for Alternating-Current Power Circuits," had been revised in 1950 and again in 1956. Each of these revisions had required 2 to 3 years of periodic meetings to discuss new and revised drafts and to perfect the exact wording of each definition and clause. This cost many thousands of dollars for travel expenses and engineering time. NEMA standards for lightning arresters were kept up-to-date by semiannual meetings costing a great deal of time, money, and effort to perfect wording satisfactory to the manufacturers. The current AIEE and NEMA standards did not agree in certain overlapping areas. This was particularly true as to definitions. Also they varied from the new American Standard definitions developed by ASA Sectional Committee *C42*. These differences confused users not familiar with the preparation of the standard, thus defeating voluntary acceptance.

The ASA Sectional Committee *C62* on Lightning Arresters had to spend 3 years with periodic meetings for discussion of numerous drafts in order to compromise the differences in these highly perfected AIEE and NEMA standards. The work of the Sectional Committee in compromising these differences between the two standards could not avoid detracting from the sense of achievement on the part of people who had spent so much time and conscientious effort to obtain perfection. This is not conducive to voluntary acceptance of the standards.

The AIEE Standards Committee recognizes the problem of wasteful duplication of effort in perfecting standards and then turning them over to an ASA Committee in its statement in the AIEE Standards Manual (5th edition) under "AIEE Standardization Activities," p. 17:

> "2. When . . . an undertaking is proposed with the expectation that it will ultimately be submitted to ASA for approval as "American Standard" it would be best to submit the proposed project to the Electrical Standards Board at an early stage with the request that the project be approved to go forward under the Sectional Committee procedure. . . . Of course, the Institute can always proceed with the development of a standard on its own account but when finished it is then decided to ask for ASA approval, in all probability much of the work would have to be done over again in a Sectional Committee. Obviously, therefore, the work should be done in the first place under a set-up that will insure final approval."

A special article recommended by the AIEE Standards Committee.

G. F. Lincks is with the General Electric Company, Pittsfield, Mass.

The author wishes to thank H. R. Armstrong, E. Beck, A. M. Salazar, and H. R. Stewart for their valued assistance in the preparation of this article.

CHANGE IN APPROACH

WITH THIS BACKGROUND, the ASA Sectional Committee *C62* has faced up to the urgent need for improving the efficiency of its product standardization. It recognized that if nothing was done, history would repeat itself. The current American Standard which it had just completed would be the "current" or "working" standard for only a short time. Gradually, it would become obsolete because of technical advancements in the industry both in systems and design. After several years, the AIEE Technical Committee and NEMA would start all over again to rewrite and perfect two separate standards that would be confusing to the users.

With this in mind, the ASA Sectional Committee *C62* decided that the American Standard should be made the working standard of the industry by keeping it continually up to date. In order to do this, NEMA and the AIEE Standards Committee approved certain changes in their respective standardization practices for lightning arresters. On NEMA's part, it will refer all its proposals for new lightning arrester standards directly to ASA *C62* without publication in the NEMA Standards, on the understanding that the new proposal, if found acceptable, will be reflected in the American Standards in a reasonable length of time. Furthermore, existing NEMA Standards after inclusion in *C62.1* will be deleted from NEMA Standards publications so that there will be no duplicate sections in simultaneous existence. NEMA will continue to publish a standard for lightning arresters containing only:

1. Standards for future design; that is, advance standards toward which the manufacturers are designing their equipment. When current designs can be certified as meeting the new standards, the change will be proposed to ASA. ASA has no equivalent standard.

2. Authorized engineering information, generally on application. It is anticipated that some time in the future the American Standards will include most of this information in a guide.

On AIEE's part, its new procedure will be to have the Protective Devices Committee, on instigation by the Lightning Protective Devices Subcommittee, recommend changes directly to the ASA Sectional Committee *C62*. The further part which the AIEE will play in the chain of approvals will appear in the later section on "New Step-by-Step Procedure." The AIEE Standards Committee also directed attention to a portion of the section in the AIEE Standards Manual (5th edition) under "AIEE Standardization Activities" on p. 17:

> "3. Regardless of which organization sponsors a standard, the Institute should, through its (technical) sessions and conferences, provide a forum for the presentation of reports, papers and discussions applying basic information for Standards projects in the electrical field."

To carry the major burden of processing revision proposals from these and all other interested sources, groups, or individuals, the ASA Sectional Committee *C62* appointed " a Working Group on Continuous Revision of American Standards on Lightning Arresters *C62.1*" with the following scope: (1) to review proposals in ASA *C62.1* and prepare them in letter ballot form for submission to parent Committee *C62;* (2) to serve to co-ordinate at the working group level the efforts of technical groups contributing to this standard; (3) to serve, on instruction from Sectional Committee *C62,* to implement activity on desirable changes in the standard through existing or new groups; (4) to make editorial changes in the standards or proposals as considered necessary or desirable. (While emphasis has been placed on the roles of AIEE and NEMA in ASA *C62* activity, it should be remembered that there are several other delegations to this Sectional Committee such as EEI, Communications, Railroads, etc.)

NEW STEP-BY-STEP PROCEDURE

THE STEP-BY-STEP PROCEDURE by which a revision will advance from proposal form to readiness for publication in a revised edition of the standard will be as follows and as illustrated in the flow chart, Fig. 1:

1. Proposals for revisions, whether originating with AIEE, EEI, NEMA, or other industry groups or individuals, should be sent to the chairman of ASA *C62.*

2. Upon receipt of this information, the *C62* chairman will take one of the following courses of action:
   a. Where proposals are received from established groups and are known to represent the desires of industry, they will be forwarded to the chairman of the Working Group on Continuous Revision of the American Standard on Lightning Arresters *C62.1,* for further processing, with carbon copies marked for the information of all delegations and for the chairman of the AIEE Protective Devices Committee.
   b. Where the proposals are received from small groups or individuals, and where it cannot be ascertained that the proposals represent the desires of industry, they will be submitted to the NEMA Lightning Protective Devices Section and the AIEE Protective Devices Committee for evaluation. Results of such evaluation reported back to the *C62* chairman will then be submitted by him to the Working Group chairman, with carbon copies as in 2a.

3. If sufficient supporting data accompanies a request for revision, the Working Group will prepare the proposal received in the proper language for *C62.1* and will co-ordinate all sections of *C62.1* which might be affected by the proposal. Where proposed revisions are not accompanied by sufficient supporting data, the Working Group will request such information from AIEE and/or NEMA.

4. With proposals prepared in a form suitable for inclusion in the standard, they will be submitted to the membership of *C62* for comments.

5. Upon receipt of approval or comments from ASA

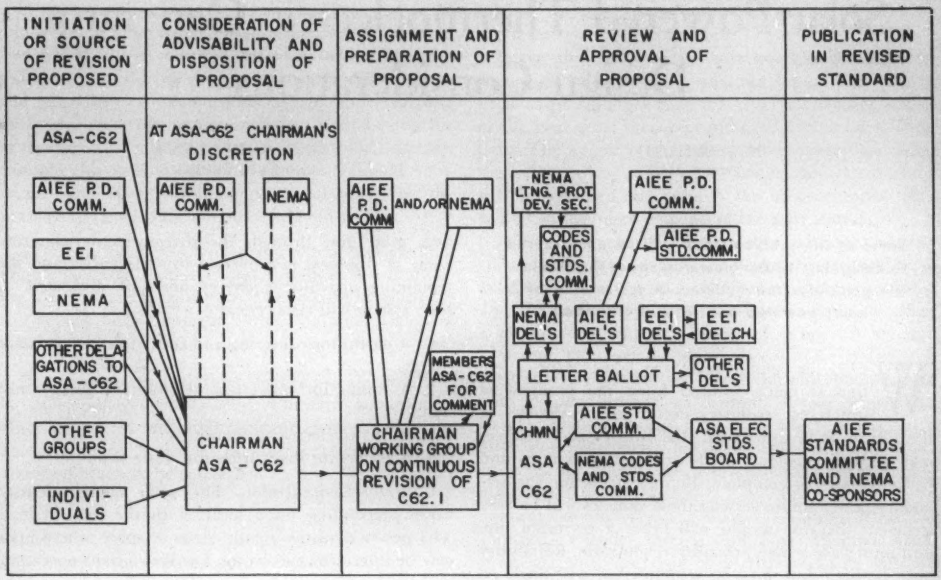


Fig. 1. Flow chart.

C62 membership, the Working Group will make such changes in the proposal as necessary and will then resubmit for *C62* letter ballot.

a. Action taken by *C62* Delegation Chairmen: (1) NEMA—Submits it to the Lightning Protective Devices Section and the Codes and Standards Committee; (2) EEI—Canvasses EEI Delegation; (3) AIEE—Transmits it to the Protective Devices Committee chairman who then submits it to the Protective Devices Committee members for letter ballot or such other type of action as he deems appropriate.

Results of this action are then communicated to the AIEE delegation to *C62* for its guidance, and a copy is sent to the AIEE Standards Committee.

b. Other *C62* delegates vote individually.

6. Upon approval, the *C62* chairman submits to the AIEE Standards Committee and to NEMA, the joint sponsors, the proposed revision of the Lightning Arrester Standard, together with the ballot tally, and full description of any negative notes.

7. After AIEE Standards Committee and NEMA approval, the revised arrester standard is submitted by the joint sponsors to the ASA Electrical Standards Board for final approval as an American Standard.

SUMMARY AND EXPECTED RESULTS

THIS NEW STANDARDIZATION PROCEDURE should provide broader participation than heretofore by all interested organizations, companies, and individuals, and thus wider voluntary acceptance. A cursory reading might indicate it gives to few people too much power, with AIEE, NEMA and others giving up normal functions. Actually, participating organizations in the ASA Section will have increased control over all changes and improvements since they review every proposal before they become standards and are published anywhere. Previously, different organizations approved and published standards in an area without any concurrence and often conflicts resulted. Each organization can draw into its review, and, if desired, balloting, as broad a representation as it deems advisable. A company or an individual can submit proposals directly. Whenever AIEE, NEMA or another organization decide a proposal requires further investigation they can recommend delaying action and either set up a study group, submit papers for discussion in AIEE, or both. Thus, everyone gains.

With this new standardization procedure there will be one American Standard on Lightning Arresters kept up to date continuously. The need at any time for completely rewriting should be eliminated. For this new standardization procedure to work successfully, changes in the American Standard must be processed quickly and then published shortly thereafter.

REFERENCES

1. New Lightning Arrester Standard, H. R. Armstrong, F. M. Defendorf, A. M. Opsahl. AIEE *Transactions*, pt. III, *(Power Apparatus and Systems)*, vol. 75, Oct. 1956, pp. 960-64.

2. When Lightning Strikes, H. R. Stewart. *The Magazine of Standards*, Aug. 1957, p. 236-38.

Solar-Powered Thermoelectric Generator Design Considerations

N. F. SCHUH
MEMBER AIEE

R. J. TALLENT
ASSOCIATE MEMBER AIEE

Some of the problems that will be encountered in designing a solar-powered space thermoelectric generator are outlined. A test model of a solar-powered generator is described.

WITH the coming space age, considerable attention is being focused upon the problem of supplying secondary power to the vehicles of the future. It is anticipated that future space vehicles may perform missions which will require months and perhaps years to complete. Requirements for the secondary power source serving these vehicles will be very stringent. Because weight will be at a premium, the unit must have a high power-to-weight ratio. Reliability must be high, but must be accomplished with little or no maintenance and without excessive redundancy. The life expectancy must be high.

Present-day systems possess a number of shortcomings which may preclude their use in extended mission vehicles. There is some doubt that these systems can be successfully modified to overcome these shortcomings. Accordingly, much effort is being expended to explore new types of power systems which will be able to meet the needs of this new age

One system that appears to show considerable merit is a solar-powered thermoelectric generator. Solar power is fairly abundant in space, and the solar-powered system would have an advantage in that it would require no fuel or shielding. The thermoelectric generator is a static conversion device and should have a fairly long life with good reliability. This article presents, in a brief manner, some of the principles and problems which may be expected in applying solar energy to a thermoelectric generator serving a space vehicle and describes a small solar-powered thermoelectric generator which was constructed to study these problems.

BASIC CONSIDERATIONS

A THERMOELECTRIC GENERATOR operates as a heat engine to convert heat statically into electricity. As such, heat must flow through the thermoelectric material. Some of this heat is converted into electricity and the remaining unavailable energy must be dissipated. A solar system will thus consist of:

1. A means for collecting and concentrating the solar energy.
2. A means for converting the radiant energy into heat.
3. A thermoelectric generator.
4. A means for dissipating the waste heat.

Collector–Concentrator. The solar energy density varies, depending upon location in the solar system. The power densities in the areas of space where man may be interested will be too low for efficient operation of a heat engine, and some means must be provided for increasing the energy density to workable levels.

Table I. Input Heat Density of Some Present-Day Thermoelectric Materials

Thermoelectric Materials	Heat Input Density, watts per square foot	Concentration Ratio Required To Supply Heat Input plus Radiation Loss
PbTe (P) PbTe (N)	1,400	26
ZnSb (P) InS (N)	5,000	61
PbTe (P) InSb (N)	4,000	51

Solar constant = 130 watts per square foot
Hot-junction temperature = 450 C (723 K)
Cold-junction temperature = 270 C (543 K)
$\alpha = \epsilon = 1.0$
Furnace factor = 0.8
Solar image area equal to load area

The energy density can be increased by collection and concentration with some type of a reflective concentrator or mirror. The optical design and construction of a large-scale reflective concentrator for a power system will be similar to that of a solar furnace. However, concentration requirements will be much less. The term "concentration ratio," as used hereafter, is defined as the ratio of the image energy density with concentration to the energy density without concentration, assuming a perfect concentrator with a reflectance of unity. Table I shows the input heat density of some present-day thermoelectric materials and the concentration ratio necessary to provide these densities in space. Note that only fairly modest ratios will be required, whereas solar furnaces usually require concentration ratios in the order of 10,000 to 30,000. A review of the published papers covering the theory and design of solar furnaces indicates that with the low concentrations required, the optical design of a power system concentrator should not be a major problem.

Condensed text of paper 59-847, presented at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959. Recommended for publication by the AIEE Air Transportation Committee. Scheduled for publication in AIEE *Applications and Industry*, 1959.

N. F. Schuh is with Westinghouse Electric Corporation, Lima, Ohio, and R. J. Tallent is with Boeing Airplane Company, Seattle, Wash.

The authors wish to acknowledge the valuable guidance of S. J. Angello and others at the Westinghouse Research Laboratory in the field of thermoelectricity and the contributions made by the members of the Materials and Processes Staff and Systems Management Office of the Boeing Airplane Company in the field of solar energy.

In space applications, the major concentrator problem is one of a mechanical nature. Because of the large area which will be required, the collector must be in a collapsed form during the ascent through the dense air and must then be extended or erected upon reaching space altitudes. The extension system must be capable of forming a large complex surface with good accuracy. Considerable work is being done by the National Aeronautics and Space Administration and others on the problem of developing suitable extension systems.

Absorber. The absorber has the function of converting the collected radiant energy into heat and conducting this heat to the generator. The conversion efficiency will depend upon the shape, surface materials, area, and temperature.

The incident energy which strikes the absorber will be either reflected or absorbed. The ratio between the absorbed energy and total incident energy defines the absorptivity coefficient of the surface. Therefore, the absorbed heat will be equal to

$$Q_a = SA_cF\alpha$$

where

α = absorptivity coefficient to solar energy

S = solar energy density, watts per square foot

A_c = area of the concentrator, square feet

F = furnace factor

Some of the absorbed heat will be lost by infrared radiation from the hot absorber surface. This loss can be expressed by the following equation:

$$Q_r = \epsilon\,\sigma\,A_a\,(T_a^4 - T_0^4)$$

where

ϵ = emissivity coefficient at the temperature of the absorber

σ = Stefan-Boltzmann constant = 5.267×10^{-8} watts per square foot per degree^4

A_a = area of the absorber, square feet

T_a = temperature of the absorber, degrees Kelvin

T_0 = effective sink temperature, degrees Kelvin

The heat available to the generator will thus be the difference between the absorbed power and the radiated heat. The heat-balance equation of the absorber can be written as follows:

$$Q_a = Q_g + Q_r$$

or

$$\alpha\,S\,A_cF = Q_g + \epsilon\sigma A_a\,(T^4 - T_0^4)$$

where

Q_g = heat delivered to the thermoelectric generator

From this equation, it is evident that the heat delivered to the thermoelectric generator will be increased when either the absorptivity is increased, the emissivity decreased, or the absorber area decreased by increasing the concentration ratio. By maximizing the power delivered, the area of the concentrator can be reduced and a saving in weight realized.

If the absorber area is made small in an effort to reduce the radiation loss and the input heat density becomes much larger than the generator density, much of the heat must then be conducted over a fairly long path. The weight of the heat-transfer system may offset the weight saving in the concentrator. Additional study will be required to optimize the absorber area with respect to the other elements of the solar system.

It is obvious that for a given absorber area, concentrator, and solar constant, the heat delivered will be a maximum when the solar absorptivity is equal to unity and the low-temperature emissivity is equal to zero. Unfortunately, materials with such properties are not available. However, in many materials the emissivity-absorptivity coefficient is not a constant but changes with temperature and wave length. It may be possible to select materials which have the property of efficiently absorbing solar energy but inefficiently radiating infrared, thus approaching the ideal material. Such materials are called selective blacks.

From the absorber heat-balance equation, it can be shown that under certain conditions, selective black materials with less than ideal characteristics will be superior to highly absorptive gray-body materials ($\alpha = \epsilon$=constant). In general, for a given concentration ratio, the selective black materials will be superior at the higher temperatures and the gray-body materials at the lower temperatures.

The absorber heat-balance equation also provides a means for calculating the temperature of the absorber. The temperature of the absorber is jointly fixed by the heat loss from the absorber surface and the heat flow through the thermoelectric generator to the radiator and thence to space. The expression defining the absorber temperature in these terms is quite complex and awkward. The calculation can be simplified by assuming the power flow through the thermoelectric generator to be a constant.

Thermoelectric Generator. A brief review of thermoelectric theory may be helpful in understanding the design problems which are described later. A thermoelectric generator is a heat engine and, therefore, the maximum available fraction of the total energy is given by the Carnot cycle efficiency. This cycle efficiency (E_c) is expressed as the difference in the heat-in and heat-out temperatures divided by the heat-in temperature in absolute degrees.

$$E_c = \frac{T_a - T_r}{T_a}$$

The portion of this available energy which can be converted by a thermocouple (called the thermocouple efficiency E_{tc}) is a function of the thermoelectric material properties and the temperature. The basic material properties are the Seebeck coefficient S (in volts per degree C temperature difference between junctions), thermal conductivity k, and electrical resistivity ρ. A

figure of merit Z relating these materials properties is expressed as

$$Z = \frac{S^2}{\rho k}$$

By considering the effects of Peltier heat, Thomson heat, and Seebeck voltage, it can be shown that the thermocouple efficiency is

$$E_{te} = \frac{\sqrt{1 + TZ} - 1}{\sqrt{1 + TZ} + T_a/T}$$

Now the over-all efficiency E of a thermoelectric generator can be expressed as

$$E = E_c E_t$$

and the electric power output available is

$$P = Q_o E_c E_{te}$$

where

Q_o = the heat flow into the thermoelectric material

It is important to note that the material properties appear only as S^2 divided by ρk in the expression for efficiency. This indicates that the material properties are important in respect to one another, but not independently.

Metals are not good materials for thermoelectric power generators, because of their low thermocouple efficiency. By plotting the figure of merit with respect to the current carrier density or resistivity, it can be shown that the best thermoelectric materials apparently lie in the semiconductor or semimetal range. Indeed, most of the materials development today is directed at thermoelements in this range. Unfortunately, semiconductors are not high-temperature materials, being limited to 500 to 700 C, as far as we know today. This means that the heat energy available in the form of burning fuels, concentrated sunlight, and nuclear reactors cannot be used at its maximum temperature and, therefore, maximum energy conversion cannot be obtained. It would be very desirable, then, to increase the efficiency by increasing the operating temperature of the thermoelement materials. A large effort is underway to convert insulator class materials into good thermoelectric materials by increasing their electrical conductivity without appreciably increasing their thermal conductivity or decreasing their Seebeck voltage. Mixed-valence materials such as lithium nickel oxide appear very promising in the 700 to 1,500 C range.

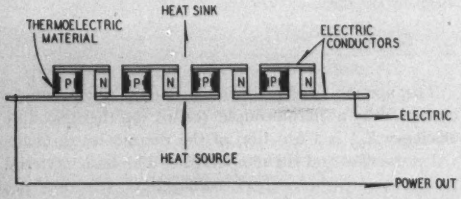


Fig. 1. Basic thermoelectric generator arrangement.

The major electrical characteristics of a thermoelectric generator can be defined by the power output, the open-circuit voltage, and the internal resistance. The power output at matched load has previously been given approximately as the product of the heat flow into the material and the over-all efficiency. The open-circuit voltage V_o is calculated from

$$V_o = N S \Delta T$$

where

N = number of thermoelements

S = Seebeck voltage

$\Delta T = T_a - T$.

The internal resistance of the generator R_g is calculated from

$$R_g = N \rho \, l/A$$

where

ρ = electrical resistivity

l/A = dimensions of the thermoelements

Maximum load power occurs when the load resistance is equal to R_g. The load voltage then is equal to $\frac{1}{2}V_o$. In the practical case, voltage drops will also occur at the contacts and in the conductors. These drops are generally assumed to be no greater than 5% of the total voltage.

The design of a thermoelectric generator will vary greatly with energy source, application, environment, and state of the art of the materials. Whatever the details of appearance, however, a heat path must be provided from the heat source, through the thermoelements, and into the heat sink, as shown in Fig. 1. In general, the elements are thermally in parallel and electrically in series, which indicates one of the problem areas in any practical design. Thermal contact areas must be good heat conductors and, at the same time, must be good insulating electrical surfaces.

Another problem area results from the relatively high operating temperatures encountered. High-temperature thermoelements must be connected together with high-temperature conductors, held together with high-temperature structural materials, and protected by high-temperature finishes. These requirements reduce the number of available materials which can be used even at nominal thermoelectric temperatures, such as 400 to 500 C.

A thermoelectric generator is essentially a low-voltage high-current device with a relatively high internal impedance. This means that the output voltage will change considerably with load. The change in load voltage with load current will not be exactly linear, because of the Peltier effect. The Peltier effect is in such a direction as to tend to cool the hot junction and heat the cold junction. As the current is reduced by increasing the load resistance, the hot and cold junction tem-

Fig. 2. Photograph of solar-powered thermoelectric generator test model. (Vacuum enclosure not shown.)

peratures tend to increase. These increases tend to be approximately the same, so that ΔT is almost constant. Deviations from linear voltage regulation are due to changes in ΔT and the resultant changes in materials characteristics with temperature change.

Because of the inherently slow response time of such a thermally operated device, good voltage regulation under load changes would be difficult to obtain by trying to control the heat flow. In most applications, it is anticipated that some form of power-conversion equipment will be used either to raise the direct voltage level or to convert direct current to alternating current. Voltage regulation can be very effectively accomplished in this conversion equipment.

Radiator. The function of the radiator is to dissipate the waste heat from the generator unit and to control the temperature of the cold junction. At the present, the radiator appears to be one of the larger problem areas in a solar-powered thermoelectric system.

In space, the only mode for heat removal is by radiation. To attain a high Carnot efficiency, the radiator temperature should be as low as practicable. However, low temperatures can be attained only with large radiator areas. With a large radiator and concentrated input, a major portion of the waste heat will be dissipated at areas somewhat removed from the source, and some means must be provided for conveying the heat to these areas.

If a solid material heat-conduction system is used, the flow of heat by conduction to the dissipative areas will cause a temperature drop. If the drops are large, extra area must be added to compensate for the reduced performance. Since this area will be added at an even greater distance from the source, the dissipative capabilities will be quite low and a point of diminishing returns is rapidly reached.

The flow of heat in a radiator is a complex problem of 2-dimensional heat flow. This problem is currently being studied with the aid of a computer. At the time of writing, detailed results have not been obtained. Approximate results indicate that if the power inputs are high and radiation temperatures low, fairly large thermal conductor cross sections will be required with attendant larger weights.

In a space solar-powered system, the efficiency of the conversion device may not be as significant as in the more familiar terrestrial applications. Solar energy is abundant and free. The main consequence of reduced efficiency will be to increase the size of the concentrator and the conversion device. Since the goal in space applications is to obtain a large power-to-weight ratio, it may be desirable to sacrifice efficiency by using higher radiator temperatures, thereby reducing the radiator weight. Optimization studies will be required to determine the best radiator temperature.

Another factor which will influence the radiator area is the orientation of the emissive surfaces. In some solar systems, the radiator will be exposed to the sun. If the radiator area is to be kept to a minimum, the heat input from the sun must be kept small. This can be done by keeping the area facing the sun small and by using suitable selective black material for the radiator surface. If good selective blacks are available or if the temperature is high, the solar energy does not significantly increase the radiator area.

In other solar systems, the radiator will be shaded from the sun but exposed to the earth (for earth-orbiting vehicles) during certain portions of the orbit.

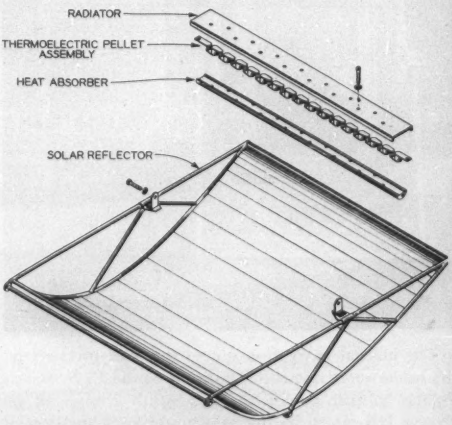


Fig. 3. Exploded view of principal elements of test model.

The earth may be considered as a black body radiating at the average temperature of the earth and reflecting a certain percentage of the solar radiation. Calculations indicate that the effect on radiator requirements is insignificant at the higher temperatures. From this work, it appears that radiator orientation need not significantly affect radiator design.

DESCRIPTION OF TEST MODEL

A REVIEW of the considerations covered in the foregoing indicated that certain problem areas will exist which are not amenable to analytical solution. To define and evaluate these problems better, a solar-powered thermoelectric model was constructed. Temperatures and outputs were established by material and size limitations. No attempt was made to optimize any part of the system or to make the model flyable. The primary objective was to construct a workable model which could be easily instrumented.

The power output was arbitrarily set at 2.5 watts. It was estimated that a minimum thermocouple efficiency of 7.7% could be achieved with today's material and that a Carnot cycle efficiency of 25% was reasonable. This gives an over-all efficiency of 1.92%. Based on this figure, a heat input to the thermoelements of 130 watts is required.

The complete model is shown in the photograph in Fig. 2 and as an exploded view in Fig. 3. It consists of a concentrator, a sidereal drive, an evacuate enclosure, a water-cooled sink, and the thermoelectric assembly.

The test model will be subjected to a series of tests designed to determine the performance of the system and to investigate the optical, thermal, and electrical problems. Theoretical considerations will be proved or disproved or otherwise evaluated by comparing calculated results with experimental data. The experience gained in designing, constructing, and testing this small model will be of considerable benefit in future solar–thermoelectric work.

REFERENCES

1. Power from Solar Energy, J. 1. Yellott. *Transactions*, American Society of Mechanical Engineers. New York, N. Y., vol. 79, no. 6, Aug. 1957, pp. 1349-59.

2. High Temperature Furnaces, Felix Trombe. *Proceedings*, Phoenix Symposium on Applied Solar Energy, Phoenix, Ariz., 1955, pp. 63-72.

3. Analysis of Large Aperture Parabolic Mirrors for Solar Furnaces, J. Farber, B. I. Davis. *Journal*, Optical Society of America, New York, N. Y., vol. 47, no. 3, Mar 1957, pp. 216-20.

4. A Segmented-Mirror Solar Furnace for High-Intensity Thermal Radiation Studies, R. Gardon. *Review of Scientific Instruments*, New York, N. Y., vol. 25, no. 5, May 1954, pp. 459-63.

5. Designing Solar Furnaces for Specific Performance, Raymond Bliss. *Journal of Solar Energy Science and Engineering*, Phoenix, Ariz., vol. 1, nos. 2-3, Apr.-July 1957, pp. 55-62.

6. Fuel for Solar Furnaces, A. R. Kassandel. *Ibid.*, pp. 44-47.

7. Solar Energy Furnaces (book), Guy Benveniste. Stanford Research Institute, Menlo Park, Calif., 1955.

8. American Institute of Physics Handbook (book), D. E. Gray. McGraw-Hill Book Company, Inc., New York, N. Y., 1957.

9. Semiconductor Thermoelements and Thermoelectric Cooling (book), A. F. Ioffe Infosearch Ltd., London, England, 1957.

10. Climatological Data, U. S. Weather Bureau. U. S. Department of Commerce, Washington, D. C., vol. 8, nos. 1-12, Jan.-Dec. 1957.

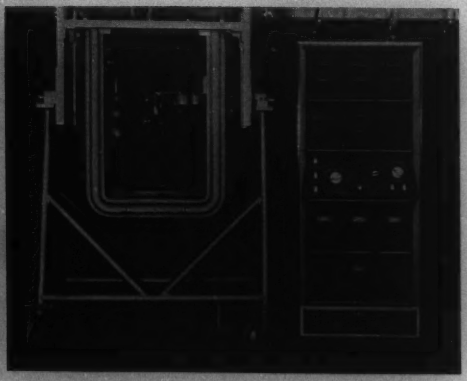
11. Optimum Reflector-Absorber Geometry for a Solar Generator, R. W. Stineman AIEE *Transactions*, pt. II *(Applications and Industry)*, vol. 78, 1959, paper no. 59-869.

12. Process Heat Transfer (book), D. Q. Kern. McGraw-Hill Book Company, Inc., 1950.

13. Heat Transmission (book), W. H. McAdams. McGraw-Hill Book Company, Inc., 1942.

14. Recent Progress in Solar Furnaces for High Temperature Research and Development Work, W. M. Conn. *Journal*, Franklin Institute of the State of Pennsylvania, Philadelphia, Pa., vol. 257, no. 1, Jan. 1954, pp. 1-11.

Polaris Submarine Autonavigator



The inertial navigation system that will precisely fix the underwater launching position of the U. S. Navy's Polaris ballistic missile has successfully completed extensive laboratory testing at Autonetics, a division of North American Aviation, Inc. The Navy and Autonetics have disclosed that a prototype engineering model of the system has been undergoing at-sea tests aboard the *U. S. S. Compass Island*.

Known as the *N7A* autonavigator, the submarine system is regarded as the key to the successful launching of the Polaris missile, which must be given exact prelaunching position information in order to reach its target accurately. The Autonetics system provides such information by incorporation of advanced gyroscopes, acceleration-sensing instruments, and a 2-in-1 (general purpose and digital differential analyzer) computer. In uncovered binnacle, shown at the left, are the inertial system's stabilized platform, precision gyrocopes, and velocity meters. All other electronic equipment is compactly packaged in the separate navigation console (*right*).

All mathematical computations for the *N7A* navigational system are performed by a digital computer, called the VERDAN. This advanced computer—approximately 1½ cubic feet in over-all size—can be programmed to permit accurate navigation over all regions of the earth.

Motorette Evaluation of Insulation Systems

H. P. BOETTCHER
ASSOCIATE MEMBER AIEE

TO UTILIZE the new materials effectively as they become available, it is necessary that searching and severe representative tests be used and the results compared to those for existing materials. From this agreement, it is possible to proceed confidently in the use of these evaluated materials. It is then possible to match more exactly an insulation system to a proposed use. Thus, the user benefits from a better and more economical electric machine.

Accelerated tests were made according to AIEE no. 510. In order to reduce variables introduced by the manufacturing process, and to be better able to show minor variations, motorettes were chosen. Two Class A systems were evaluated. One of these systems was used by all co-operating laboratories of the AIEE Working Group on Insulation Evaluation. The other system was one for which there was motor test data as well as considerable field experience. Fig. 1 is a comparison of the temperature-life data. From a practical standpoint, there is no significant difference between the two curves. The third curve shows the results of accelerated motor tests. The difference in test voltage is probably the greatest cause of discrepancy between the motor and motorette tests. It was amazing to see how little insulation was left on the motors several cycles before actual failure; the visible parts of the end turns looked completely bare. In planning to co-ordinate motors and motorette test values, special effort should be made to evaluate both on the same reasonable basis. Actually the two curves shown possess excellent agreement; much better than should be expected.

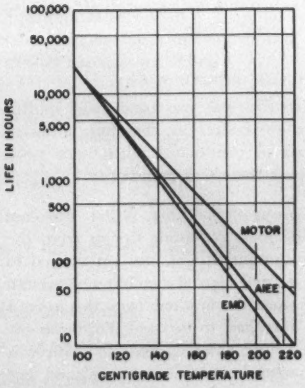


Fig. 1. Comparison of AIEE system and EMD system motorette and EMD system motor temperature-life characteristics.

To be able to evaluate new Class B (130 C) systems it was first necessary to establish a standard. Two courses were open: (1) comparison with an existing Class B system or (2) to define arbitrarily the life required at the maximum operating temperature. Of course, it is most desirable if the two methods agree. From extensive past experience on Class A systems and from tests made, the life at the maximum temperature (105 C) is both known and known to be satisfactory. The obvious preliminary definition of Class B is that this system should possess the same life at 130 C as the Class A system had at 105 C. After having established a base, the limits can be specified for Class B (130 C) and Class F (155 C) systems as a system that possesses 10,000 to 20,000 hours life at the respective maximum temperatures when extrapolated from accelerated tests. The test results for the standard Class B system closely approach our arbitrary requirements and demonstrate the validity of the initial assumptions. Using this double criterion, new systems may be evaluated.

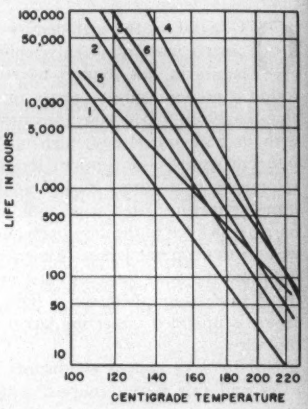


Fig. 2. Temperature-life characteristics for newer materials.

Fig. 2 shows the temperature-life characteristics of several other systems which were evaluated. The tests in each case followed the AIEE procedures except the voltage between parallel conductors was increased to 120 volts. Results obtained by other members of the Working Group indicated a greater consistency in end point determination with this turn to turn voltage. In addition to the specified tests, the insulation resistance was measured on the completion of each cycle. This gave us some indication of the rate of deterioration and the point of impending failure. All motorettes were constructed with the same size wire to remove this as a possible variable.

Digest of paper 58-1280, "Results of Motorette Evaluation of Insulation Systems," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Pittsburgh, Pa., Oct. 26-31, 1958. Published in AIEE *Transactions*, vol. 77, pt. III, 1958 (Feb. 1959 section), pp. 1459-63.

H. P. Boettcher is with the A. O. Smith Corporation, Milwaukee, Wis.

The Design and Manufacture of Direct Burial Wire

J. L. ROBB
ASSOCIATE MEMBER AIEE

W. L. ROBERTS

A discussion of the design and manufacturing techniques of a direct burial wire that compares favorably in cost with open-wire construction in areas where high-speed wire plows can be used.

OUTSIDE of the high-density service areas in the central parts of cities, telephone operating companies in this country have, until recent years, found it economically necessary to use aerial distribution facilities. Open-wire construction in particular, with its high initial cost, high maintenance cost, and frequent service interruptions fostered a desire for development of a direct burial facility. Various efforts using rubber-insulated wire with no outer protection failed, which led to the development of rubber-insulated wires with neoprene jackets. Experience in certain areas indicated the need for additional mechanical and electrical protection; therefore a light, flat, ribbon steel armor is provided under the jacket in certain types of this wire.

No. 16 Awg copper conductors are used in these wires and this factor, coupled with the costs of the rubber and neoprene, results in a product which is economically prohibitive in many situations. In light of this condition, the development of lower-cost facility was started in 1956.

PERFORMANCE REQUIREMENTS

ENGINEERS of the Rural Electrification Administration (REA) anticipated extensive use of a low-cost buried wire facility if such could be developed and, therefore, established performance requirements for a wire which would meet the needs of the REA telephone program:

1. Attenuation and d-c resistance must be small enough to permit total loop lengths, including some cable plant, to reach a large proportion of subscribers who would normally be served by 1- or 2-circuit open-wire construction, without exceeding transmission limits and supervisory limits for presently available central office equipment. Loops of about 15 miles in length would probably be necessary.

2. All materials used in the wire should be suitable for use both above and below ground, and a life expectancy of 20 to 25 years for the wire would be necessary.

3. The wire must be armored for protection against small rodents and termites.

4. A shield for lightning protection and noise mitigation must be used and a tentative shield resistance of 15 ohms per 1,000 feet was established.

5. The wire must have a breaking strength of approximately 500 pounds to permit installation with high-speed wire-plowing equipment and to withstand ground heaving and frost cracks. A further consideration was the intended use of this wire for "aerial inserts" and for aerial drop wire.

6. The wire will be in contact with treated wood poles at terminal points and must withstand exposure to pole-treating chemicals, particularly creosote and pentachlorophenol.

7. The cost of the wire in place must be competitive with first costs for open-wire construction.

8. Some carrier circuit potential would be desirable, but not mandatory.

A study by REA engineers indicated that a wire with no. 19 Awg copper conductors and a mutual capacitance of 0.083 microfarad (μf) per mile would meet transmission and supervisory requirements. By coincidence these are the characteristics of a no. 19 Awg cable pair. This same study proposed the use of black weather resistant polyethylene as the insulant and offered suggested dimensions for the insulated core so proportioned that the minimum amount of insulating material would be used to achieve the desired mutual capacitance. This same study also proposed the use of flat, ribbon steel as a combined armor-shield-strength member.

DESIGN OF BURIED WIRE

ECONOMY DICTATED that the two conductors in this wire be insulated in one operation; therefore, a design using a parallel pair of conductors with black polyethylene extruded over them was mandatory.

Shape and Dimensions of the Core. A flat oval core appeared to offer the most economic design from the standpoint of minimum amount of insulant needed to achieve the desired mutual capacitance but since a flat, ribbon steel armor must be applied over this core a more nearly round core had to be used. Formulas for proportioning of a round shielded pair to achieve a desired mutual capacitance have been published but

Essentially full text of a paper recommended by the AIEE Wire Communication Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer and Pacific General Meeting and Air Transportation Conference, Seattle, Wash., June 21-26, 1959.

J. L. Robb and W. L. Roberts are with the Superior Cable Corp., Hickory, N.C.

there was no information available on the proportioning of a core which was approximately elliptical.

Greene, Leibe, and Curtis, in an article appearing in the *Bell System Technical Journal* (1936), have indicated that to obtain minimum capacitance for a flat oval shielded pair a spacing ratio of approximately 0.47 should be used. The spacing ratio is defined, in the case of the flat oval (Fig. 1), as the quotient obtained by dividing the interaxial conductor spacing S by the major diameter M_a. The mutual capacitance of the flat oval circuit is very slightly greater than that of the shielded double coaxial circuit with an equal cross-sectional area. The total cross section of the flat oval circuit is

$$A = 2RS + \pi R^2 \tag{1}$$

where

$$M_a = S + 2R$$

One conductor of a double coaxial circuit of equal cross section would have a radius of

$$R_1 = \sqrt{\frac{1}{2\pi}(2RS + \pi R^2)} = R\sqrt{\frac{S}{\pi R} + \frac{1}{2}} \tag{2}$$

The capacitance of the double coaxial circuit is given by the well-known relation

$$C_1 = \frac{0.0194\,\epsilon}{\log_{10}\dfrac{2R_1}{d}} \text{ uf per mile}$$

where d is the conductor diameter.

It is obvious (from Fig. 1) that the capacitance of the flat oval circuit is less than that of a double coaxial circuit with similar insulation whose outside radius is $S/2$ (where $S < 2R$). Then, if C represents the capacitance of the flat oval circuit,

$$\frac{0.0194\,\epsilon}{\log_{10}\dfrac{2R}{d}\sqrt{\dfrac{S}{\pi R} + \dfrac{1}{2}}} < C < \frac{0.0194\,\epsilon}{\log_{10}\dfrac{S}{d}} \tag{3}$$

Furthermore, if 0.47 represents the optimum spacing for minimum capacitance, a similar oval of equal cross section, but having a spacing ratio of 0.50, would have a greater capacitance. Then

$$C < C' < \frac{0.0194\,\epsilon}{\log_{10}\dfrac{S'}{d}}$$

where

$$S' = 2R$$

Since the cross sections are equal

$$2R'S' + \pi R'^2 = 2RS + \pi R^2$$

After substituting

$$S' = (1.091)S$$

Equation 4 may then be reduced to

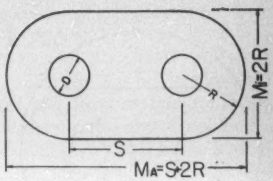


Fig. 1. Cross section of flat oval circuit.

$$\frac{0.0194\,\epsilon}{\log_{10} 1.165\,\dfrac{S}{d}} < C < \frac{0.0194\,\epsilon}{\log_{10} 1.091\,\dfrac{S}{d}} \tag{4}$$

where

$$\frac{S}{S + 2R} = 0.47$$

For a mutual capacitance of 0.090 μf per mile or a smaller volume and an insulation with a dielectric constant of 2.5 or greater, the average value of those obtained from equation 4 must be correct to within ±3.5%.

As indicated previously, the flat oval configuration presents manufacturing difficulties in the armoring operation. The quasi-elliptical cross section used may be regarded as a compromise between the flat oval circuit and the circular-shield balanced pair.

The capacitance of a balanced pair with a circular shield whose diameter is equal to the major diameter of the flat oval (Fig. 2) is given approximately by

$$C_c \approx \frac{0.0194\,\epsilon}{\log_{10}\dfrac{2S}{d}\left[\dfrac{\sigma^2 - 1}{\sigma^2 + 1}\right]}$$

where

$$\frac{D}{S} = \sigma = \frac{S + 2R}{S}$$

This reduces to

$$C \approx \frac{0.0194\,\epsilon}{\log_{10} 1.276\,\dfrac{S}{d}} \tag{5}$$

When

$$\frac{S}{S + 2R} = 0.47$$

For shield configurations lying within the area bounded by the flat oval and circular shields, the capacitance of the circuit is less than the upper limit indicated by equation 4, greater than the value obtained from equation 5.

The following equation has been found to be accurate to within ±2.3% when applied to constructions with M_i/M_a ratios ranging from 0.52 to 0.75, and spacing ratios between 0.45 and 0.51:

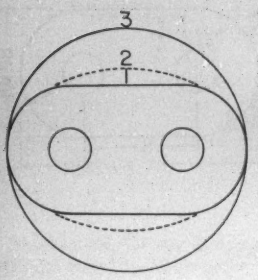


Fig. 2. Comparison of shield configurations: (1) flat oval; (2) quasi-elliptical; (3) circular.

$$C \approx \frac{0.0194\,\epsilon}{\log_{10}\frac{2S}{d}\left[\frac{M_a^2 - S^2}{M_a^2 + S^2}\right] - 0.167\log_{10}\frac{M_a}{M_i}} \quad \mu f \text{ per mile} \qquad (6)$$

(The dielectric constant of general purpose black polyethylene may vary by as much or more than ±2.3%. This deviation is apparently due to variation in the carbon black content and perhaps also to the moisture content of the compound.)

For the flat oval circuit with a spacing ratio of 0.47, equation 6 can be reduced to

$$C \approx \frac{0.0194\,\epsilon}{\log_{10} 1.146\,\frac{S}{d}} \quad \mu f \text{ per mile} \qquad (7)$$

Equation 7 appears consistent with the inequalities expressed in equation 4. Equation 6 does not account for the shift of the optimum spacing ratio from 0.486 to 0.47, as the shield configuration changes from a circle to a flat oval.

Fig. 3 shows calculated mutual capacitance as a function of S/d for several M_i/M_a ratios with the spacing ratio fixed at 0.47.

Capacitance Unbalance and Resistance Unbalance. When buried wire is used in the field, it must be anticipated that open-wire circuits and drop wires will be connected to the buried wire and, therefore, noise voltages induced in these facilities will be impressed on the buried wire. To minimize the effects of these noise voltages, capacitance unbalance to the shield and conductor resistance unbalance must be held to low levels.

In the previously mentioned rubber-neoprene buried wire, a capacitance unbalance maximum of 500 μμf per 1,000 feet is permitted. This seemed to be a reasonable figure and was adopted for the polyethylene-insulated wire. In the case of the rubber-neoprene wire, however, this value is met by measuring the capacitance unbalance on a completed reel of wire and then, if the maximum value is exceeded, cutting the wire at the midpoint and splicing it together again with the conductors reversed. It was felt that this procedure was not necessary with the polyethylene-insulated wire since it was anticipated that precise control of the polyethylene extrusion would produce wire within the capacitance unbalance limits. Manufacturing experience, however, indicated that a higher maximum value was needed to avoid excessive rejected material so a maximum value of 750 μμf per 1,000 feet was adopted.

When this higher value of maximum capacitance unbalance was adopted, installation procedures in the field were changed to require that the two conductors of the buried wire be reversed at every terminal point. Since terminals appear on the average every 1/4 mile, this should control both capacitance unbalance and resistance unbalance very adequately.

Because a reversal of conductors at every terminal is required, it is necessary to identify each conductor in the buried wire. An easy and convenient means of doing this is to have one conductor tinned or plated.

The resistance unbalance limit for this wire is based on experience with other no. 19 Awg copper conductors and is set at 1.5 ohms maximum per 1,000 feet.

Armor-Shield-Strength Member The necessity for protection against rodents and termites, along with the breaking strength required of the buried wire, plus the importance of low cost, indicated the use of steel for this function.

Based on measurements of samples produced early in the development program using steel armor, a shield resistance of 15 ohms per 1,000 feet appeared feasible but later large-scale production showed that the steel chemistry needed to meet the electrical and tensile properties was quite precise; so, rather than sacrifice the electrical properties of the shield which are at best marginal, the breaking strength requirement was reduced to 400 pounds.

Efforts to improve the conductivity of the shield and at the same time provide a measure of corrosion resistance by the use of galvanized or copper covered steel were unsuccessful due to the cost of these materials.

It was recognized, however, that damage to the jacket of the wire and exposure of the steel during installation must be expected; therefore, some method of corrosion protection was needed. It was decided that a thermoplastic flooding compound flooded over the steel armor during the jacketing operation would protect the steel

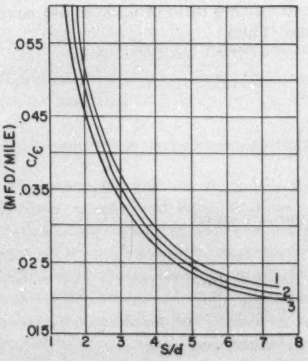


Fig. 3. Mutual capacitance graphs: (1) flat oval circuit; (2) quasi-elliptical circuit; (3) circular shielded circuit (spacing ratio = 0.47; cross sections not equal.

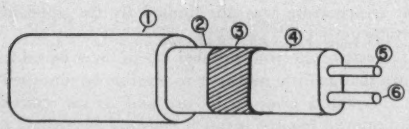


Fig. 4. Direct burial wire: (1) polyvinyl chloride jacket; (2) thermoplastic flooding compound; (3) flat steel armor-shield; (4) polyethylene core; (5) bare copper conductor; (6) tinned copper conductor.

to a degree and would serve the further purpose of filling the interstices between the armor ribbons, thereby preventing the entrance of water under the jacket. The flooding compound provided a very low-cost answer to this problem, but created another problem.

One intended use of this wire was an "aerial drop wire" in buried plant construction. Drop wires are attached to buildings and should be able to withstand a vertical flame test. The presence of the flooding compound causes the wire to be nonself-extinguishing. A type of flooding compound containing a flame retardant is currently under development which, it is believed, will overcome this difficulty.

Buried Wire Jacket. Because of the aforementioned selfextinguishing need, a polyvinyl chloride jacket was used. This jacket provides the necessary toughness and will stand reasonable exposure to the common pole-treating chemicals, as well as provide the desired life above and below the ground.

The jacket offers no resistance to rodents or termites. The effects of soil bacteria and fungi on these jackets have not been evaluated, but no difficulties are anticipated from these sources.

Now that this wire has been in use in the field, it has developed that a method of indicating the footage on the surface of the jacket would be desirable. Since the route of the buried wire during installation is somewhat devious, conventional methods of chaining the line to determine the amount of wire used are inaccurate. Polyvinyl chloride lends itself to this type of surface marking and preliminary developments indicate that it will be feasible to provide this marking on the wire.

MANUFACTURE OF BURIED WIRE

THE MANUFACTURING TECHNIQUES used to produce buried wire are standard extrusion and wire armor serving techniques, but there are certain problems which have occurred that merit discussion.

Conductors. The application of tin or other materials as a plating on one of the copper conductors for polarity identification in this wire causes certain problems.

It is standard practice to draw wire to the finished size and then to apply the tin over this diameter. As a result, tinned conductors will be very slightly larger in diameter than bare wire of the same gauge number. Also, standard specifications for tinned wire in no. 19 Awg permit a plus tolerance of 3%, while for bare wire the plus tolerance is 1%.

As a result of these factors, the tinned wire runs slightly larger than the bare wire and when these two different wires are paired, the direct capacitance to the shield is consistently higher for the tinned conductor.

This "built-in" unbalance, when added to the normal variations that occur in the extrusion of the core and application of the armor, results in unbalances which are greater than the permissible maximum for an undesirable percentage of the total wire produced. To overcome this, it is necessary that the tinned conductor be the same diameter as the bare conductor within close tolerances.

When two conductors of the same diameter are used, the capacitance unbalances become random rather than systematic, and the values are within limits.

Reducing the diameter of the tinned conductor, however, causes this conductor to run consistently high in resistance but still within resistance unbalance limits. This situation is, of course, corrected by the practice of reversing conductors at terminal points in the field.

Extrusion of the Core. Considerable difficulty was experienced in verifying the calculated design for the desired mutual capacitance owing to the presence of voids along the conductor surface. These voids along the conductor surface tended to lower the mutual capacitance significantly. The presence of the voids in the insulation lowers the dielectric strength and cannot be controlled to yield consistent values of mutual capacitance; therefore, it was necessary to eliminate this condition.

The effect of the voids on mutual capacitance was calculated using a simple coaxial structure with a composite dielectric inasmuch as it was felt that this would be indicative of the order of magnitude of mutual capacitance variation that could be expected with the two conductor shielded pair.

For the purpose of comparison, a coaxial-type construction with a no. 16 Awg conductor and 0.100 inch wall of polyethylene with $\varepsilon=2.6$ was chosen.

The potential difference equation as given in "Electric and Magnetic Fields," by S. S. Attwood (p. 80) is:

$$V_1 - V_2 = \frac{\rho_L}{2}\left(\frac{1}{\epsilon_b}\,1n\,\frac{r_2}{r_1} + \frac{1}{\epsilon_c}\,1n\,\frac{r_3}{r_2}\right)$$

This yields a capacitance of:

$$C = \frac{0.0388}{\frac{1}{\epsilon_b}\log\frac{r_2}{r_1} + \frac{1}{\epsilon_c}\log\frac{r_3}{r_2}}\ \mu f \text{ per mile}$$

Where

ϵ_b = dielectric constant of void (=1)

ϵ_c = dielectric constant of polyethylene (2.6)

r_1 = conductor radius (or diameter)

r_2 = dielectric boundary radius (or diameter)

r_3 = shield radius (or diameter)

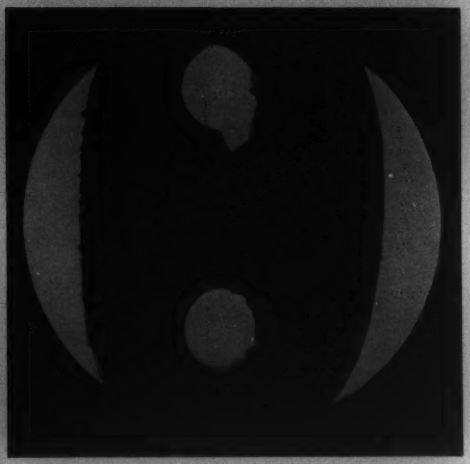


Fig. 5. Photograph of core cross section showing void formations adjacent to conductor surfaces.

The construction cited (16 Awg, 0.100 inch wall, ε_e=2.6) yields the following values:

For no void space around conductor: $C = 0.144$ μf per mile

For 0.001 inch average void space around conductor: C=0.139 μf per mile

For 0.002 inch average void space around conductor: C=0.134 μf per mile

For 0.003 inch average void space around conductor: C=0.129 μf per mile

The capacitance decreases expressed as percentages amount to:

For 0.001 inch void space: 3.5%

For 0.002 inch void space: 6.9%

For 0.003 inch void space: 10.4%

The presence of the voids was apparently the result of the presence of moisture in the carbon black used in the black polyethylene; therefore, a series of experimental runs were conducted starting with natural polyethylene and proceeding with black compounds having 0.025%, 0.041%, 0.058%, 0.075%, 0.088% moisture contents, respectively. The natural polyethylene yielded a smooth, dense, void-free core as did the black polyethylene with a moisture content of 0.025%. The compound with 0.041% moisture content was relatively free of voids but all the other compounds resulted in gross void formation.

In those compounds where voids formed, it was found that high conductor preheat temperatures aggravated the void situation; while removing the preheat caused the insulation to shrink away from the conductor, creating an equally unfavorable condition. With the low moisture content compounds, the upper preheat temperature was not limited by the appearance of voids.

To control the void problem, steps must be taken to insure that as little moisture as possible be absorbed by the compound prior to its use and to use extrusion techniques to remove as much moisture as possible during extrusion. Hopper dryers, fine mesh screen packs to improve mixing and increase back pressure, and tools designed to increase head pressure are all beneficial.

CONCLUSION

Over 1,000 miles of this type of buried wire have been installed in the field and experience to date indicates that the design objectives of this wire were sound. The carrier capabilities of this facility are quite limited but electronic developments may eliminate this shortcoming. Such developments may also extend the loop limit capabilities of this wire.

The design of buried wire has stabilized and manufacturing problems have been solved so that this product is now available as a standard outside plant facility at a cost which compares favorably with open-wire construction in those areas where high-speed wire plows can be used. It is reasonable to expect that in coming years a substantial amount of this type of telephone distribution facility will be buried directly in the ground.

REFERENCES

1. Buried Telephone Plant in Residential Areas, W. J. Lally, C. C. Lawson. *Bell Laboratories Record*, New York, N. Y., vol. 37, no. 3, March 1959, pp. 105-9.

2. Design of Wire and Cable for Direct Burial in Rural Telephone Systems of REA Borrowers, R. S. Baily, C. R. Ballard, F. F. Farnsworth, A. L. Richey. U. S. Signal Corps Sixth Annual Symposium, Asbury Park, N. J., 1957.

3. Communication Underground Distribution Plant in Urban Areas, C. H. Elder. U. S. Signal Corps Sixth Symposium, Asbury Park, N. J., 1957.

4. Buried Rural Telephone Distribution Systems, D. G. Wilson. U. S. Signal Corps Sixth Annual Symposium, Asbury Park, N. J., 1957.

5. Buried Cable Telephone Systems, G. L. Chilberg. AIEE *Transactions*, vol. 76, pt. I, 1957, pp. 130-35.

6. The All-Buried Telephone Service Concept, J. S. Reed. *Telephone Engineer and Management*, vol. 62, nos. 7 and 8, Chicago, Ill., April 15, and May 1, 1958.

7. The Proportioning of Shielded Circuits for Minimum High-Frequency Attenuation, E. I. Green, F. A. Leibe, H. E. Curtis. *Bell System Technical Journal*, New York, N. Y., vol. 15, no. 2, April 1936, pp. 248-83.

8. Electric and Magnetic Fields (book), S. S. Attwood. John Wiley & Sons, Inc., New York, N. Y., 1949, pp. 79-80.

Embossing Machine

A completely automatic single character embossing machine, the Electronic Datatyper *410*, manufactured by Dashew Business Machines, Inc., Culver City, Calif., operates at an average speed of 14,000 characters per hour in embossing plates directly from punch cards for use in credit card plans, addressing, accounting, and stock control systems, and as identification tags for industrial equipment and supplies. These plates are also used extensively by the U.S. Armed Forces, serving as shipping tags as well as source documents for accounting control.

Subtransient Reactances of Synchronous Machines

K. B. MENON

THE THEORETICAL approach so far made in the development of formulas for the direct- and the quadrature-axis subtransient reactances is based on either proportioning the current in the pole-tip bar, depending on its permeance, or evolving an equivalent damper winding on the assumption of sinusoidal distribution of damper currents. Both these methods have their limitations when applied to the case of salient pole synchronous machines. The purpose of this digest is to outline an accurate method of determining the subtransient reactances by estimation of the induced magnetomotive force of each of the rotor circuits in terms of the applied sinusoidal armature magnetomotive force from a knowledge of the field forms for the two axes and the leakage permeances of the damper and the field windings.

Any general method for calculation of the reactance as a result of armature reaction flux in the air gap of synchronous machines must be applicable to all conditions of operation, whether steady-state, transient, or subtransient. The leakage flux reactance associated with the armature winding has to be added to the reactance of armature reaction to obtain the values of steady-state, transient, and subtransient reactances.

Equations in the general form are derived for the subtransient reactances in the direct and the quadrature axes. Flux-linkage equations obtained by the application of the concept of constant flux-linkage theorem to each of the rotor circuits are converted into flux-density equations involving flux-distribution coefficients and ratios of permeances of damper and field leakage to that of the air gap. A typical set of curves for the field forms and flux-distribution coefficients together with a diagram indicating the order of numbering the damper bars with respect to the two axes is given in Fig. 1. A set of simultaneous equations have to be solved to get the values of air gap flux densities resulting from induced currents in the damper and field circuits in terms of the maximum value of flux density produced by corresponding armature currents. The number of equations will be equal to the number of rotor circuits to be considered in each axis. Since the damper circuits per pole are usually not more than five or six, the solution of the equations does not present much difficulty. Calculation of the per-unit value of subtransient reactances for the two axes is, thereafter, an easy matter. The criterion for the accuracy of the reactance formula—that the formula can be reduced to the well established equation for the reflected secondary reactance of the squirrel-cage induction motor —is substantiated by the general expressions developed for the direct- and the quadrature-axis reactances of armature reaction.

Calculation of subtransient reactances by the present

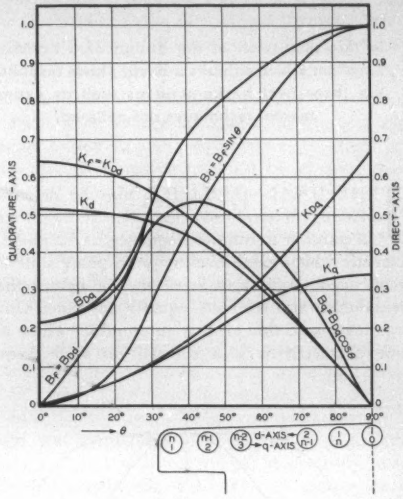


Fig. 1. Flux density and flux distribution coefficient curves for the direct and the quadrature axes.

rigid method involves the determination of the flux-distribution coefficients and the evaluation of the leakage permeances of the field and damper circuits. Distribution coefficients are simple to obtain with sufficient accuracy from the field forms for the two axes. Interpolar fringing field can be plotted from Carter's curves for the main field and the direct- and the quadrature-axis armature reaction fields. The major difficulty will be in the determination of leakage permeances of the damper circuits which have been considered electrically independent of one another. The accuracy of the method depends on how correctly the values of these permeances can be assessed.

A comparison of subtransient reactances for the two axes obtained from expressions given by L. A. Kilgore (AIEE *Transactions*, vol. 50, Dec. 1931, pp. 1201-13) and by the present method shows that there is appreciable difference between the two sets of calculated values. The results also indicate that there is error in assuming that the damper magnetomotive force is sinusoidal in space distribution.

Digest of paper 59-3. "An Accurate Method of Calculation of Subtransient Reactances of Synchronous Machines," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Published in AIEE *Power Apparatus and Systems*, June, 1959, pp. 371-79.

K. B. Menon is with the Indian Institute of Technology, Kharagpur, India.

Linear-Phase Transistor Amplifier

PETER HIRSCH

In this discussion of the design of a transistor amplifier which exhibits a linear phase response, the theoretical background as well as experimental techniques are outlined.

THE IDEAL AMPLIFIER may be described as having an amplitude characteristic which remains a constant to infinite frequency, and a phase characteristic which exhibits either zero phase shift for all frequencies, or at least is of such a nature that all frequencies are retarded equally in time. One approximation to this ideal is an amplifier whose amplitude characteristic is a constant to some frequency higher than the greatest frequency of interest, and whose phase characteristic is linear to that same frequency. The present discussion is concerned with the design of the latter type of transistor amplifier, with particular emphasis upon the linearization of the phase response. The effect of such linearization upon the amplitude and step response will be discussed.

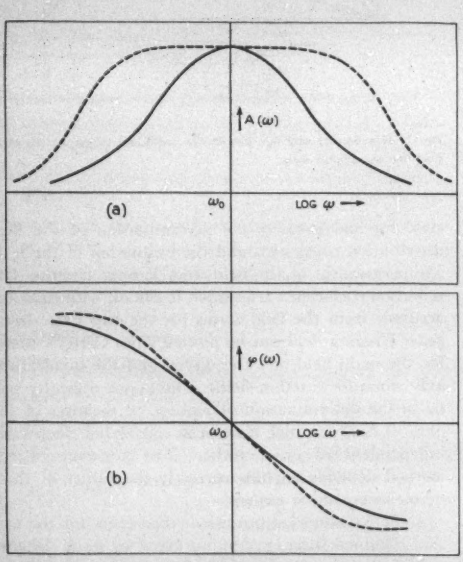


Fig. 1. (a) An even function of logarithmic frequency and a maximally flat function; (b) An odd function of logarithmic frequency and a maximally linear function.

THEORETICAL BACKGROUND

THE PROBLEM is to find a relationship among the network elements wherein the amplitude and phase characteristics of the amplifier are as desired. The viewpoint is simplified if it is realized that the same mathematical technique can be used to adjust amplitude response, or phase response, or both.[1] In Fig. 1, the amplitude response, shown as a solid line in part (a), of a bandpass structure will be an even function of logarithmic frequency, whose odd-numbered derivatives are all identically zero at midband. It can be shown that if the even derivatives are successfully adjusted to zero at midband, the function will flatten out to take the form of the dotted curve, and is then called "maximally flat." The phase response of this same structure, the solid line of Fig. 1 (b), is an *odd* function of logarithmic frequency, but its first derivative is an even function. Thus, the first derivative of the phase response can be treated in the same way as is the amplitude response in order to attain flatness at midband. If the first derivative of a function is maximally flat, then the function itself is said to be "maximally linear." The linear phase function takes the form of the dotted curve in Fig. 1(b). If now the bandpass structure is transformed into a low-pass structure, midband is zero frequency. It is clear that the derivative adjustment technique lends itself to the design of a network the amplitude and phase response of which approximate the ideal over a finite band. The degree of adjustment is defined by how many of the even-numbered derivatives of the even function are adjusted to zero. Thus, if only the second derivative is zero, the adjustment is of first degree. Of course, all the odd-numbered derivatives are zero by nature of the function.

BEHAVIOR IN THE COMPLEX FREQUENCY PLANE

IT WILL BE SHOWN that the response of a simple shunt-peaked transistor amplifier is characterized in the s plane by two poles and a zero. The generalized transfer function is

$$T(s) = K\frac{s+z}{s^2+2\xi\omega_n s+\omega_n^2} \qquad (1)$$

The zero is defined as that frequency at which the transfer function vanishes; that is, $s = -z$. The poles are defined as the frequencies at which the transfer function becomes infinite; that is, the frequencies at

Essentially full text of paper awarded first prize in the District No. 3 Student Prize Paper Contest, April 25, 1958.

Peter Hirsch, formerly a student at the Polytechnic Institute of Brooklyn, is now with Bell Telephone Laboratories, Inc., Whippany, N. J.

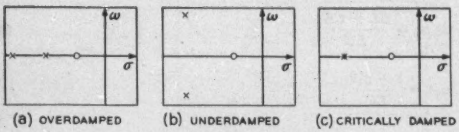


Fig. 2. Stable pole-zero configurations.

which the denominator of the function vanishes, for which

$$s = -\omega_n(\xi \pm j\sqrt{1-\xi^2}) \tag{2}$$

There are three stable possibilities for the locations of the poles in the s plane (Fig. 2): (a) They can lie on the negative real axis, and the circuit will be said to be overdamped; (b) The poles can be complex conjugates with negative real parts, in which case the circuit will be said to be underdamped; (c) The poles coincide on the negative real axis, in which case critical damping exists. In this discussion, the overdamped case will not be considered. The reasons for this choice will become clear.

Fig. 3 defines the variables used in the discussion. The absolute distance of the poles from the origin is ω_n, the distance of the zero from the origin is z, and ξ is the damping factor. It can readily be shown that $\xi = \cos\theta$. Thus, when $\theta = 0°$, it follows that $\xi = 1$ and, as θ increases, ξ decreases.

A question which immediately presents itself is: "What are the positions of the zero and the poles which characterize maximally linear phase or maximal flatness?"

To answer this question, the technique of derivative adjustment can be applied separately to the phase and amplitude response of the generalized transfer function (see Appendix). As a result, a relationship is obtained among ξ, ω_n, and z which can be plotted in the complex-frequency plane. Fig. 4 plots the loci of the poles as ξ varies. Of the two loci, one corresponds to first-degree maximally flat amplitude response, the other to maximally linear phase response. For clarity, only that pole is shown whose imaginary part is positive; the other pole yields a mirror image of the locus of the first. The representation is of the complex plane normalized with respect to z; that is, the zero is assumed fixed at $s/z = 1$. Examining the two loci, one arrives at several interesting conclusions:

1. If ω_n is finite and $z \to \infty$, the system is characterized by the two poles only. $\omega_n/z \to 0$, and one observes the well-known fact that $\theta = 45°$ (or $\xi = 1/\sqrt{2}$) for maximally flat amplitude response and that $\theta = 30°$ (or $\xi = \sqrt{3}/2$) for maximally linear phase.

2. It is *not* possible to realize both maximal flatness and linear phase simultaneously.

3. It *is* possible to realize critical damping and maximal flatness simultaneously.

4. It is also possible to realize critical damping and linear phase simultaneously.

5. It appears that a compromise can be made between maximal flatness and linear phase if the poles are allowed to move into the region between the two loci.

6. From the viewpoint of overshoot in the step response of the system, the condition of linear phase seems preferable to that of maximal flatness. That is, for any ω_n/z ratio, linear phase indicates the lesser overshoot.

Inasmuch as the figure gives no readily discernible indication of the change in bandwidth with ξ, it seems desirable to plot ω_n and z separately as functions of ξ. To do this, an actual circuit must be investigated.

THE CIRCUIT

THE CIRCUIT is considered to be one stage of a cascade of identical common-emitter shunt-peaked low-pass transitor amplifier stages. The equivalent circuit assumed for the transistor is the frequently used hybrid-π model, Fig. 5 (a).

It is further assumed that g_{oe} is small enough to be negligible if the amplifier drives another common emitter stage. The model is simplified by replacing $g_{b'c}$ and $C_{b'c}$ by their Miller representation at the input,[2] and combining the resulting $(1 + g_m R_L)C_{b'c}$ and $(1+g_m R_L)g_{b'c}$ with $C_{b'e}$ and $g_{b'e}$, respectively, to give as the final model Fig. 5 (b). The a-c circuit for the complete stage and its load (which is assumed to be an identical stage) is then shown in Fig. 5 (c). The forward voltage transfer ratio of this configuration is

$$\frac{E_o}{E_i}(s) = \left(\frac{-g_m}{C}\right)\frac{s + \frac{R}{L}}{s^2 + \frac{GL + CN}{LC}s + \frac{1 + GN}{LC}} \tag{3}$$

where

$$N = R_L + r_{bb'}$$

Comparing with the generalized transfer function, equation 1, it is seen that

$$z = \frac{R}{L}$$

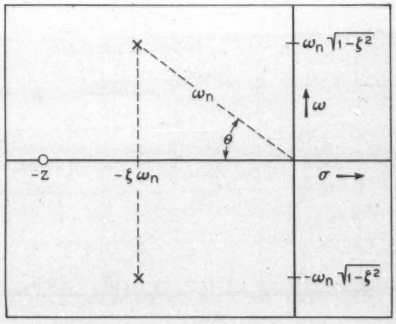


Fig. 3. Poles and zeros of equation 1.

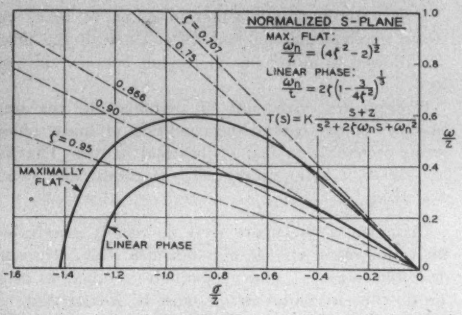


Fig. 4. ω_n/z ratio vs. damping factor for maximally flat amplitude response and linear phase response.

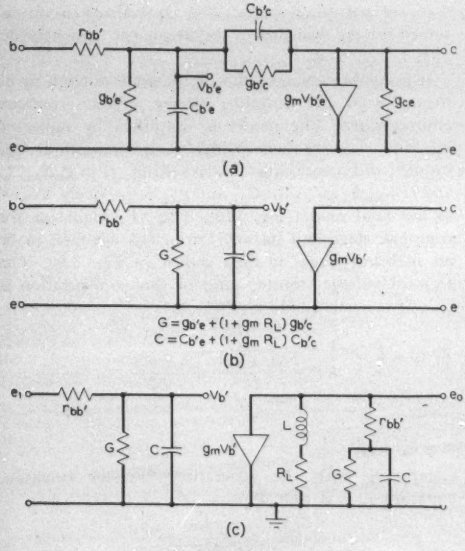


Fig. 5. Equivalent circuits.

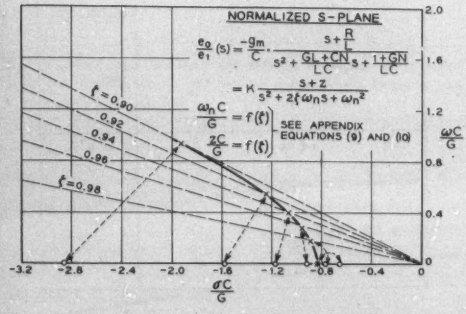


Fig. 6. Pole-zero locations for linear phase response.

$$2\xi\omega_n = \frac{GL + CN}{LC} \qquad (4)$$

$$\omega_n^2 = \frac{1 + GN}{LC}$$

and the two last expressions can be solved simultaneously for ω_n and ξ. Proceeding with the solution, one finds that ω_n and z can be expressed in terms of C/G and ξ. Thus ω_n and z can be normalized with respect to C/G and plotted vs. ξ.

Fig. 6 shows the relationships between the normalized positions of the poles and the zero for first degree maximally linear phase response. Both $\omega_n C/G$ and the corresponding zC/G are plotted for $0.9 \leqq \xi \leqq 1.0$. G/C makes a useful normalization factor, because it is the input time constant of the transistor. Again, for clarity, the pole possessing a negative imaginary part has been left off the figure, which now gives an indication of the change in bandwidth with ξ. In the actual circuit chosen, the minimum value of ξ has been increased to approximately 0.89, from a previous value (which was arrived at by assuming the only restriction on the locations of the poles and the zero was the condition of the linear phase) of $\xi \geqq 0.866$. It can be shown that a value of $\xi < 0.89$ in the circuit under consideration would require both the zero and the poles to move out to infinity (see Appendix).

As before (from Fig. 4), Fig. 6 shows that critical damping and linear phase can be realized simultaneously, but it can now be seen that this condition can be realized only at the expense of a reduction in bandwidth. Indeed, it will be shown later that simultaneous linear phase and critical damping can be achieved only if one is willing to sacrifice nearly all of the improvement in gain-bandwidth product that the compensation scheme otherwise offers. (The same type of graph can be plotted for the condition of first degree maximally flat amplitude response; the mathematical procedure is identical.)

A further point of interest, from the viewpoint of step response, is the relative distance from the origin of the poles and the zero at different values of ξ. If ξ is close to 0.9, then $z > |\omega_n|$, but as $\xi \to 1.0$, $z < |\omega_n|$. When the poles are complex, the presence of the zero tends to increase the overshoot in the step response. However, since $z > |\omega_n|$ for the larger number of cases where $\xi < 1$, and since ξ is close to unity at all times, the effect is minor. At the other extreme, where the circuit is critically damped and there is no overshoot, the response is speeded up by the presence of the zero close to the origin.

The ratio of C to G normally remains fairly constant for any particular transistor, regardless of circuit configuration or bias. Thus, once the linear phase response, ξ, and the particular transistor have been specified, both the bandwidth and the d-c gain are fixed. This is in contrast to the vacuum-tube amplifier, where gain can be traded for bandwidth under the same conditions, and only their product remains constant. The

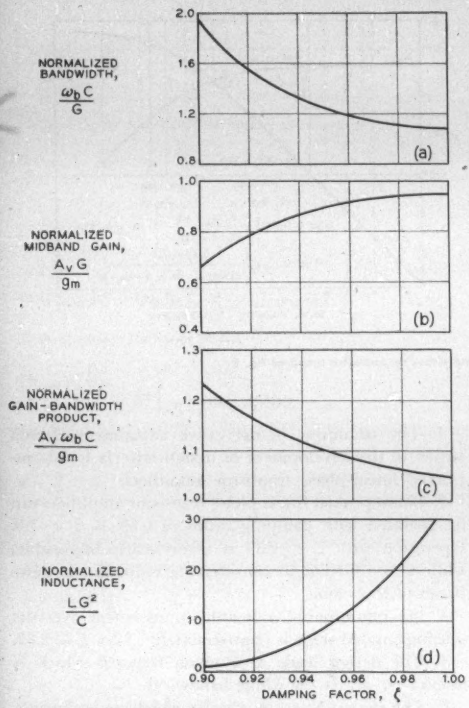


Fig. 7. Normalized bandwidth, midband gain, gain-bandwidth product, and inductance vs damping factor.

difference in behavior can be traced directly to the presence in the transistor amplifier of the input shunt conductance.

Fig. 7 (a) indicates the variation of normalized bandwidth with ξ. Here ξ is plotted linearly along the abscissa, and the bandwidth is normalized to G/C, the transistor input time constant. The bandwidth is defined as the frequency at which the gain drops 3 db from its d-c value (see Appendix). It is interesting to note that the normalized bandwidth is always greater than unity, with highest bandwidth at the lower value of ξ.

Fig. 7 (b) shows the variation of normalized d-c gain with ξ. Here the gain is normalized with respect to $g_m/G \approx \beta$ (the transistor common-emitter short-circuit current gain.) As could have been predicted, the forward voltage gain is less then the short-circuit current gain at all values of ξ. The current gain is reduced by insertion loss, and approximately equals the voltage gain, because source and load impedances are very nearly identical.

Fig. 7 (c) shows the variation of normalized gain-bandwidth product with ξ. It is normalized with respect to g_m/C, which is an approximate figure of merit corresponding to g_m/C_0 in a pentode. Significantly, the normalized gain-bandwidth product is always greater than unity, but decreases as $\xi \rightarrow 1.0$. As previously pointed out, this is the price which must be paid for simultaneous critical damping and linear phase response.

A further point of interest is the highest obtainable gain-bandwidth product with linear phase. A study of the curve shows that as $\xi \rightarrow 0.89$, the normalized gain-bandwidth is about 1.3, although it is doubtful that one could attain a value in excess of 1.2 under linear phase conditions in an actual circuit. It has been shown in an unpublished communication of M. V. Joyce and K. K. Clark, Polytechnic Institute of Brooklyn, that the maximum normalized gain-bandwidth product approaches 1.6 for a maximally flat shunt-peaked transistor amplifier. Thus, there is a clear indication that linear phase response necessitates reduced gain-bandwidth.

Fig. 7(d) is a plot of normalized inductance vs. ξ. The curve is significant from the point of view of physical design, and shows a further disadvantage to the simultaneous realization of critical damping and linear phase. The inductance necessary to achieve linear phase becomes rapidly larger as critical damping is approached. This large inductance is a decided liability in terms of increased shunt capacitance, space requirements, and cost. On the other hand, the rapid increase of inductance with ξ is advantageous in that a relatively large change in inductance would appear to have little effect on circuit behavior.

EXPERIMENTAL TECHNIQUE

In order that the actual effect of the compensating network on the phase shift could be studied, several circuits (see Fig. 8) were built and their phase shifts measured as a function of frequency. The inherent problems of accuracy in phase-shift measurements placed a severe upper limit on the frequencies at which such measurements were feasible. It was decided, therefore, to build only circuits which did not require measurements beyond 300 kc. Nevertheless, it is felt that these compensation techniques are applicable at all frequencies where the single pole representing the input

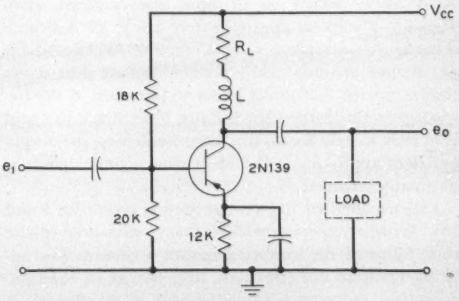
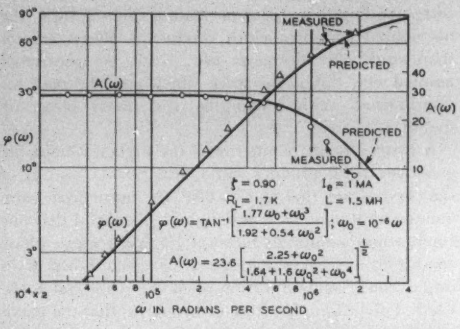
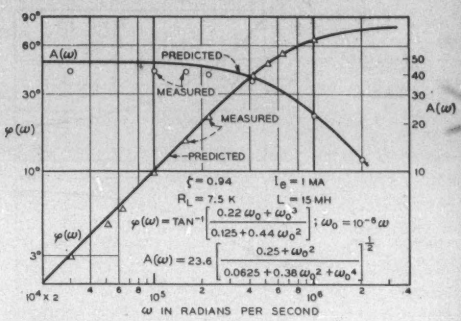


Fig. 8. The experimental circuit.


MEASURED
PREDICTED
A(ω)
PREDICTED
MEASURED
ξ = 0.90
I_e = 1 MA
R_L = 1.7 K
L = 1.5 MH
φ(ω) = TAN⁻¹ [1.77 ω₀ + ω₀³ / 1.92 + 0.54 ω₀²] ; ω₀ = 10⁻⁶ ω
A(ω) = 23.6 [2.25 + ω₀² / 1.64 + 1.6 ω₀² + ω₀⁴]^½
φ(ω)
A(ω)
ω IN RADIANS PER SECOND


A(ω)
PREDICTED
MEASURED
MEASURED
PREDICTED
ξ = 0.94
I_e = 1 MA
R_L = 7.5 K
L = 15 MH
φ(ω) = TAN⁻¹ [0.22 ω₀ + ω₀³ / 0.125 + 0.44 ω₀²] ; ω₀ = 10⁻⁶ ω
A(ω) = 23.6 [0.25 + ω₀² / 0.0625 + 0.38 ω₀² + ω₀⁴]^½
φ(ω)
A(ω)
ω IN RADIANS PER SECOND

Figs. 9 (*left*) and 10 (*right*). Amplitude and phase response for circuit of Fig. 8.

time constant of a transistor determines its uncompensated response. Beyond an upper limit of a few megacycles, the hybrid-π model is no longer valid, and a transistor cannot be considered to be characterized by a single pole in the complex frequency plane.

A word is warranted concerning the relative difficulties of phase-shift measurement in transistor and vacuum-tube circuits. Such measurement, to any fair accuracy, is acknowledged to be difficult in vacuum-tube circuits, since, at the high impedance levels encountered, the stray capacitances of the measuring equipment produce serious difficulties. In a transistor circuit, the impedance levels are usually low—in the order of a few kilohms at most. (For example, the input capacitance of the RCA *2N139* is 2,000 μμf at $I_e = 1$ milliampere) Thus, stray capacitance can be virtually ignored, and the measurement problem reduces to the search for an indicator of phase shift in the circuit. The method used here was to compare the phase shift of a simple low-pass *R-C* circuit with that of the amplifier, by means of a Lissajous pattern on an oscilloscope. The capacitor was adjusted until the phase shifts were equal. Phase shift in degrees was then calculated from the frequency and the *R-C* product.

EXPERIMENTAL VERIFICATION

THE PARTICULAR TRANSISTOR chosen for study was the RCA *2N139*, which has an input time constant, when $V_{ce} = -9$ volts, at approximately 2.5×10^{-6} second. This figure corresponds to beta cutoff of 400 kiloradians per second. A study of the predicted phase shift shows that it remains essentially linear to just short of the frequency at which the gain is down 3 db. Since the gain is approximately flat to this same frequency, the amplifier does approximate the ideal over a finite band, as originally intended.

Experimental results were uniformly good (Fig. 9 and 10). Within experimental accuracy, measured phase shift followed the predicted quantity closely. The adjustments were not critical—a 10% change in the compensating inductance caused a very small change in phase shift, primarily at very low frequencies.

CONCLUSIONS

1. The technique of derivative adjustment is well suited to the development of design criteria for shunt-peaked linear-phase transistor amplifiers.

2. Shunt-peaked linear-phase transistor amplifiers can be operated with damping ratios of $0.89 \leq \xi < 1.0$. Operation with $\xi < 0.89$ is theoretically impossible, while $\xi > 1.0$ leads to considerable reduction in gain-bandwidth product.

3. Maximum gain-bandwidth improvement over the uncompensated stage is approximately 1.3 for $\xi = 0.89$.

4. The design leads to a phase response which is linear over nearly the whole bandwidth.

5. The design leads to circuits which are relatively insensitive to variations in the compensating inductance.

6. The effect of transistor base-spreading resistance can be virtually ignored when the circuit is operated at the optimum values of damping ratio.

Appendix

Derivation of Relationship Among ω_n, z, ξ for First-Degree Linear Phase Response:

$$T(s) = K \frac{s + z}{s^2 + 2\xi\omega_n s + \omega_n^2} \tag{5}$$

$$\therefore \Phi(\omega) = \tan^{-1}\left[\frac{\omega_n^2 - 2\xi\omega_n z}{\omega_n^2 z}\omega - \frac{(\omega_n^2 - 2\xi\omega_n z)(2\xi\omega_n - z)}{\omega_n^4 z^2}\omega^3 + \ldots\right] \tag{6}$$

For first-degree maximally linear phase response[1]

$$\frac{(\omega_n^2 - 2\xi\omega_n z)(2\xi\omega_n - z) + \omega_n^2 z}{\omega_n^4 z^2} = -\frac{1}{3}\left[\frac{\omega_n^2 - 2\xi\omega_n z}{\omega_n^2 z}\right]^2$$

From which

$$\frac{\omega_n}{z} = 2\xi\left[1 - \frac{3}{4\xi^2}\right]^{\frac{1}{2}}$$

Derivation of Relationship Among ω_n, z, ξ for First-Degree Maximally Flat Amplitude Response

$$T(s) = K \frac{s + z}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

$$\left| T(j\omega) \right|^2 = \frac{K^2 z^2}{\omega_n^4} \left[\frac{1 + \frac{\omega^2}{z^2}}{1 + \frac{\omega^2}{\omega_n^2}(4\xi^2 - 2) + \left(\frac{\omega}{\omega_n}\right)^4} \right]$$

For first-degree maximally flat amplitude response[1]

$$\frac{1}{z^2} = \frac{1}{\omega_n^2}(4\xi^2 - 2)$$

$$\therefore \frac{\omega_n}{z} = (4\xi^2 - 2)^{\frac{1}{2}}$$

Derivation of Further Restriction on ξ

From condition for linear phase:

$$\frac{\omega_n}{z} = 2\xi \left[1 - \frac{3}{4\xi^2} \right]^{\frac{1}{2}}$$

From the circuit:

$$z = \frac{R}{L}$$

$$2\xi\omega_n = \frac{GL + CN}{LC}$$

$$N = R_L + r_{bb'}$$

$$\omega_n^2 = \frac{1 + GN}{LC}$$

Then $4\xi^2 \left(1 - \frac{3}{4\xi^2}\right)^{\frac{1}{2}} = 1 + \frac{GL + Cr_{bb'}}{R_L C}$

But $\frac{GL + Cr_{bb'}}{R_L C}$ must be positive and real

$$4\xi^2 \left(1 - \frac{3}{4\xi^2}\right)^{\frac{1}{2}} - 1 > 0$$

From which $\xi > 0.89$

Derivations of Expressions for Pole and Zero Positions, Voltage Gain, Inductance, and Bandwidth

From condition for linear phase response:

$$\frac{\omega_n}{z} = 2\xi \left[1 - \frac{3}{4\xi^2} \right]^{\frac{1}{2}} \tag{7}$$

$$= 2\xi\Delta$$

where

$$\Delta = \left[1 - \frac{3}{4\xi^2} \right]^{\frac{1}{2}}$$

From the circuit:

$$z = R/L$$

$$2\xi\omega_n = \frac{GL + CN}{LC} \tag{8}$$

$$\omega_n^2 = \frac{1 + GN}{LC}$$

Then $\frac{GL}{CR} \approx 4\xi^2\Delta - 1 \quad (\text{for } r_{bb'} \ll R_L)$

POLE

$$\therefore \frac{\omega_n C}{G} \approx \frac{2\xi\Delta}{4\xi^2\Delta - 1} \tag{9}$$

ZERO

$$\frac{ZC}{G} \approx \frac{1}{4\xi^2\Delta - 1} \tag{10}$$

VOLTAGE GAIN

Since midband voltage gain $= A_v = \frac{g_m N}{1 + NG}$

$$\frac{A_v G}{g_m} = \frac{NG}{1 + NG} \tag{11}$$

where

$NG = f(\xi)$

INDUCTANCE

Also

$$\frac{G^2 L}{C} = \frac{RG}{RC/GL} \approx \frac{NG}{zC/G} \quad (\text{for } r_{bb'} \ll R_L) \tag{12}$$

BANDWIDTH

Since $\left| T(j\omega) \right|^2 = K^2 \frac{z^2 + \omega^2}{\omega_n^4 + \omega^2 \omega_n^2 (4\xi^2 - 2) + \omega^4}$

$$\therefore \left| T(0) \right|^2 = \frac{K^2 z^2}{\omega_n^4} \tag{13}$$

Let the bandwidth $= \omega_b$

where

$$\left| T(j\omega_b) \right|^2 = \frac{1}{2} \left| T(0) \right|^2$$

Define

$$\omega_0 = \frac{\omega_n C}{G} \; ; \; z_0 = \frac{zC}{G}$$

Then

$$\frac{\omega_b C}{G} = \frac{\sqrt{\omega_0^4 - \omega_0^2 z_0^2 (2\xi^2 - 1) + \sqrt{\left[\omega_0^4 - \omega_0^2 z_0^2 (2\xi^2 - 1)\right]^2 + \omega_0^4 z_0^4}}}{z_0} \tag{14}$$

REFERENCES

1. The Role Played by Derivative Adjustment in Broadband Amplifier Design, W. A. Lynch. *Proceedings*, Symposium on Modern Network Synthesis, Microwave Research Institute, Polytechnic Institute of Brooklyn, Brooklyn, N. Y., Apr. 1952.

2. Common Emitter Video Amplifiers, G. Brunn. *Proceedings*, Institute of Radio Engineers, New York, N. Y., vol. 44, Nov. 1956, pp. 1561-72.

Effect of Elevated Temperature on Flash-Welded Aluminum–Copper Joints

C. R. DIXON
ASSOCIATE MEMBER AIEE

F. G. NELSON

As a result of improved techniques, the quality of flash-welded joints between aluminum and copper has been greatly improved so that they can now be made commercially. To evaluate these techniques, tests were made on 500 joints and the effects of heating on tensile strength, ductility, resistance to impact, and electrical resistance were determined.

BOTH ALUMINUM and copper have high conductivity and, hence, are excellently suited for use as electric conductors. Since both metals are widely used, connections between them frequently have to be made. The most common type of connection is the bolted joint, as when an aluminum bus bar is bolted to a copper stud. Although this type of connection is satisfactory, frequently a more efficient and less bulky connection, with better appearance, can be made by flash welding (Fig. 1).

The quality of flash welds is dependent on certain conditions during the welding operation. As a result of important improvements in techniques, especially in the forging mechanism and in the die design of the welding equipment, flash welding is now used commercially in an increasing number of applications in which connections have to be made between aluminum and copper. The improvements provide (1) rigid support of the pieces at the ends during joining, (2) large increase of velocity of the platen at the time of upset, and (3) control of time of change from flashing to upsetting during the flash-welding operation. These three improvements make it possible to obtain welds of high quality. Furthermore, the die not only rigidly supports the material but uses the energy of motion to shear off the upset metal.

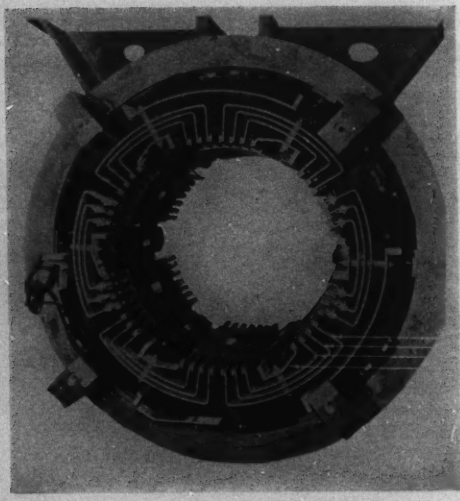


Fig. 1. Stator of large generator containing flash-welded aluminum–copper joints. (Arrows indicate one of 24 groups of welds; note bend near one weld.)

While it is possible that extreme temperature conditions might be harmful to the joints, it was believed that the conditions that would exist in normal service would not be harmful. Some tests to evaluate the effects of elevated temperatures were reported several years ago, using joints made before the present improved techniques were available.[1] In the investigation now being described, the improved techniques have been used. From tests of almost 500 joints, the effects of heating on tensile strength, ductility, resistance to impact, and electrical resistance were determined.

WELDING PROCEDURE AND MATERIALS

A GENERAL VIEW of the 250-kva flash-welder that was used is shown in Fig. 2. A close-up of the dies, indicating the pinching-off action at the weld, is shown in Fig. 3. An oscillogram of the operation during the controlled change of platen movement, when the velocity of the platen changes from 0.125 inch per second to 13.7 inches per second, is shown in Fig. 4, together with traces for voltage and current.

Joints were prepared consisting of commercially pure aluminum bar, ¼ by 1½ inch, flash-welded to copper bar of the same size.

The conditions under which the welds were made are shown in Fig. 5. Before making any welds to be tested, the setup of the welding machine was checked by qualification tests in which sample welds were required to withstand bending 90 degrees around a ¾-inch mandrel without failure.

Essentially full text of paper 59-1162 "The Effect of Elevated Temperature on Flash-Welded Aluminum–Copper Joints," recommended by the AIEE Committee on Electric Welding and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 11-16, 1959. Scheduled for publication in AIEE *Applications and Industry*, 1959.

C. R. Dixon is with the Alcoa Process Development Laboratories, New Kensington, Pa; F. G. Nelson is with Alcoa Research Laboratories, New Kensington, Pa.

Table I. Average Results of Tensile Tests

Heating Conditions		Tensile	Number of	Total	Extension of 2-inch Gage
Temperature (fahrenheit)	Time	Strength (psi)	Failures at Weld	Number of Tests	Length* (percent)
Group A					
	(Months)				
75	0	11,000	0	10	
	6	11,200	0	10	
	12	11,200	0	9	
	24	11,500	0	10	
212	6	11,000	6	10	6.9
	12	11,000	3	9	8.7
	24	12,000	1	6	21.0
300	6	11,400	0	9	
	12	11,200	0	6	
	24	11,100	2	9	9.8
370	3†	11,800	0	6	
	6†	11,000	0	4	
	12†	10,900	0	6	
Group B					
	(Months)				
212	24	14,800	3	4	7.7
300	6	15,200	0	1	
	12	15,100	1	3	11.5
	24	15,000	1	1	17.0
370	3†	15,500	0	4	
	6†	15,600	0	6	
	12†	15,200	0	4	
Group C					
	(Hours)				
75		15,400	7	10	9.3
450	96	14,000	7	9	10.3
	120	13,300	8	9	5.5
	144	12,200	8	8	5.2
500	6	15,400	3	10	13.5
	12	14,200	3	9	13.5
	24	12,500	3	10	14.2
	36	11,900	3	10	14.5
	48	10,100	6	10	10.9
	72	6,500	10	10	4.0
550	½	13,900	8	10	11.9
	1	12,000	7	10	8.6
	1½	11,700	4	8	7.4
	2	12,600	5	9	10.4
	3	10,500	8	9	13.1
600	¼	12,100	3	10	10.0
	½	12,500	1	8	7.5
	1	10,800	4	9	14.9
	1½	11,800	2	10	16.0
	2	11,500	2	10	10.2
700	1/12	10,300	6	10	9.7
	¼	9,400	10	10	6.6

* Includes only those that failed at weld.
† Intermittent instead of continuous heating; total time at temperature

Fig. 2. General view of 250-kva flash-welding machine.

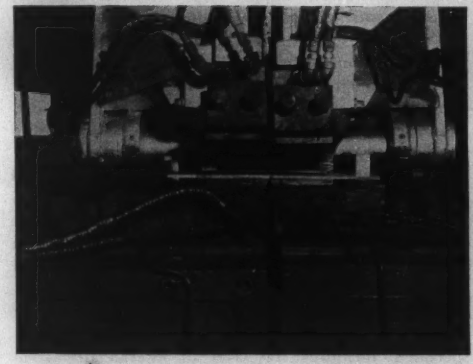


Fig. 3. Close-up showing "pinch-off" dies in flash-welding machine.

The joints consisted of three groups. Groups A and B were welded at the same time, the only difference being that the aluminum bar used for Group A had been annealed while that used for Group B was in an intermediate strain-hardened temper. The third group, C, was welded some two years later using bar similar to that used for Group B.

TEST PROCEDURES

Joints from Groups A and B, as shown in Table I, were tested either after holding at room temperature or after heating continuously at temperatures of 212 or 300 F for different periods, including some as long as 2 years. In addition, some were heated intermittently at 370 F for a total time at temperature of one year. Joints from Group C were heated continuously at tem-

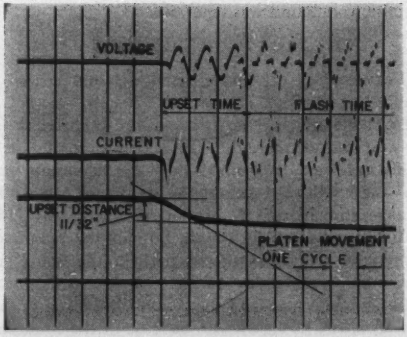


Fig. 4. Oscillogram indicating speed of platen during flash welding.

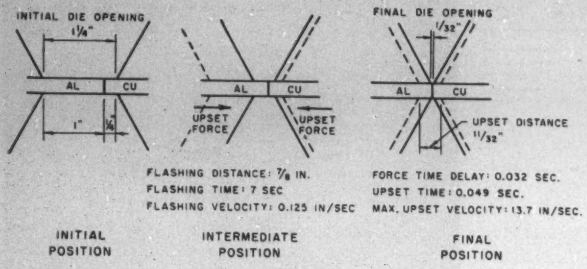


Fig. 5. Conditions used in flash welding ¼- by 1½-inch bars.

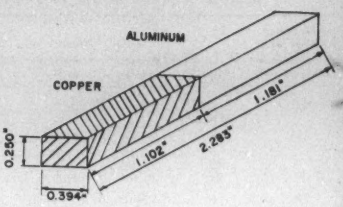


Fig. 6. Cantilever-beam impact test specimen of flash-welded aluminum–copper joint.

peratures of 450 to 700 F for periods ranging from a few minutes to 6 days.

All tests were made at room temperature. They included tensile and impact tests, electrical resistance measurements and metallographic examinations.

Tensile tests were made of specimens consisting of the full section of the bar. As a measure of ductility, the extension in per cent of a 2-inch gage length, centered across the weld, was determined.

Impact test specimens 0.250 by 0.394 inch as shown in Fig. 6 were machined without notches and were tested as cantilever beams in an Izod machine of 50 foot-pound capacity. The aluminum end of the specimen was gripped in the vise with the joint at the edge of the jaws. The copper end was struck on a 0.394-inch face by the pendulum so that an original surface was subjected to maximum tension.

Electrical resistance measurements were made in which current was passed through the length of the specimen, including the layer of intermetallic compound. The potential drops were measured over 2- and 4-inch gage lengths, using a Leeds & Northrup type *K-2* potentiometer.

Metallographic examination of some of the welds was made in which the thickness of the layer of intermetallic compound was determined.

RESULTS AND DISCUSSION

THE RESULTS of tensile tests are summarized in Table I and in Figs. 7, 8, and 9.

In about 40% of the tests, failure occurred in the aluminum and, therefore, the actual strengths of the welds were not determined—only the maximum stress that they withstood before the specimens failed. The average strength of all of the specimens was 11,900 pounds per square inch (psi), but for the reason just stated, the actual average strength of the welds must have been even higher.

In Groups A and B (Table I and Figs. 7 and 8) there was obviously no significant decrease in the strength of the specimens as a result of heating. It will be noted that in both groups, the slight decreases in strengths

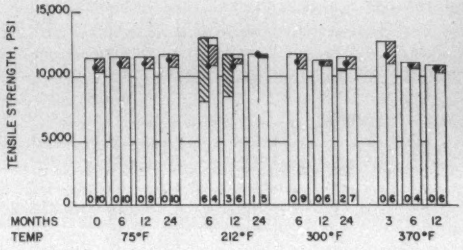
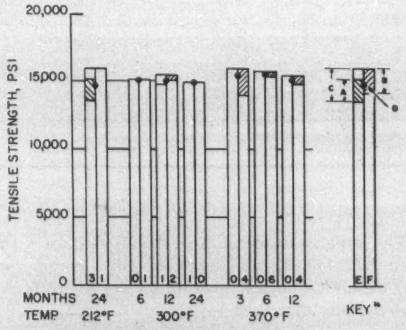


Fig. 7. Tensile strengths at room temperature after indicated exposures —Group A (for key, see Fig. 8).



*KEY: A - RANGE FOR SPECIMENS THAT FAILED AT WELD
B - RANGE FOR SPECIMENS THAT FAILED IN ALUMINUM
C - RANGE FOR ALL SPECIMENS
D - AVERAGE FOR ALL SPECIMENS
E - NUMBER OF SPECIMENS THAT FAILED AT WELD
F - NUMBER OF SPECIMENS THAT FAILED IN ALUMINUM

Fig. 8. Tensile strengths at room temperature after indicated exposures—Group B.

with increases in length of heating period at the highest temperature (370 F) are not an indication of loss of strength of the welds, since none of the failures in these tests occurred at welds. Since very few of the specimens

in Groups A and B failed at the welds, the higher strengths in Group B reflect the higher strength of the aluminum bar in those specimens.

In Group C (Table I and Fig. 9), the percentage of failures at the welds was larger than in Groups A and B. This is true regardless of whether or not the joints were heated. Also, heating at the various conditions caused decreases in strengths of the specimens. Decreases of this kind were expected because such heating would anneal the aluminum which in this group of specimens, as mentioned previously, was in a strain-hardened temper. When the decreases that occurred were accompanied by definite increases in the proportion of failures at the welds, and when the strengths became less than that of thoroughly annealed aluminum, then there was distinct evidence that the heating was detrimental to the welds. For the heating conditions investigated, the percentage of failures at the weld did not increase significantly until the specimens had been heated 120 hours at 450 F, 48 hours at 500 F, or ¼ hour at 700 F. The average tensile strength did not decrease to less than 10,000 psi until the specimens had been heated 72 hours at 500 F or ¼ hour at 700 F. In general, the scatter or spread of strengths was no greater for the exposed specimens than for those that were not heated, but the lowest individual strengths encountered for exposures of 48 hours or more at 500 F and for all times at higher temperatures were considerably below 10,000 psi.

In general, the extension values obtained in the tensile tests are in agreement with the foregoing observations.

The results of the impact tests are summarized in Table II. Values are shown only for those tests in which complete fracture occurred, because it is only under such conditions that the results have quantitative meaning.

Complete fracture occurred in only about one-fourth of the tests, and in those cases, it was at the weld. Generally, the percentage of complete fractures tended to decrease with increase in temperature. Although the average impact values were generally lower for the specimens that had been heated than for the specimens

Table II. Results of Impact Tests

Heating Conditions		Total Number of Tests	Complete Fractures		
Temperature (fahrenheit)	Time		Number of Tests	Range of Values (foot-lb.)	Average Value (foot-lb.)
Groups A and B					
	(Months)				
75	0	9	0		
	6	9	1	2.3	2.3
	12	9	1	3.2	3.2
	24	9	2	6.6–6.6	6.6
212	6	9	2	2.4–3.7	3.0
	12	9	1	0.9	0.9
	24	9	1	1.6	1.6
300	6	9	2	2.9–7.7	5.3
	12	9	0		
	24	9	2	2.4–8.0	5.2
370	3*	9	3	3.7–12.1	7.2
	6*	9	0		
	12*	9	1	1.6	1.6
Group C					
75		4	2	1.5–8.0	4.8
	(Hours)				
450	96	9	5	0.5–6.0	2.4
	120	9	9	0.5–7.5	2.3
	144	9	5	0.3–2.5	1.3
500	6	9	3	2.1–2.5	2.2
	12	9	2	1.3–4.1	2.7
	24	9	2	2.5–3.3	2.9
	36	9	1	1.1	1.1
	48	9	3	1.0–8.5	4.1
	72	9	6	1.0–4.5	2.9
550	½	9	1	4.8	4.8
	1	9	0		
	1½	9	2	0.5–2.5	1.5
	2	9	1	1.5	1.5
	3	9	1	1.0	1.0
600	¼	9	2	2.5–5.5	4.0
	½	9	1	0.5	0.5
	1	9	1	2.2	2.2
	1½	9	0		
	2	9	2	0.2–1.8	1.0
700	1/12	9	3	0.8–2.0	1.6
	¼	9	5	1.0–5.1	2.5

* Intermittent instead of continuous heating; total time at temperature

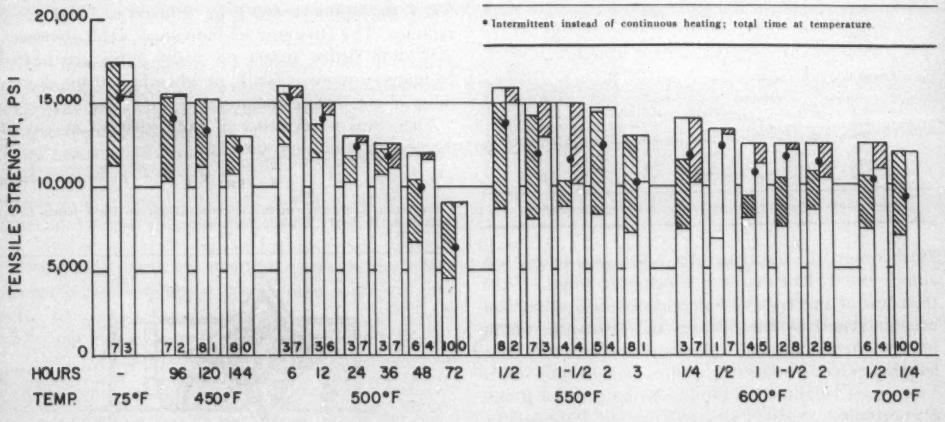


Fig. 9. Tensile strengths at room temperature after indicated exposures—Group C (for key, see Fig. 8).

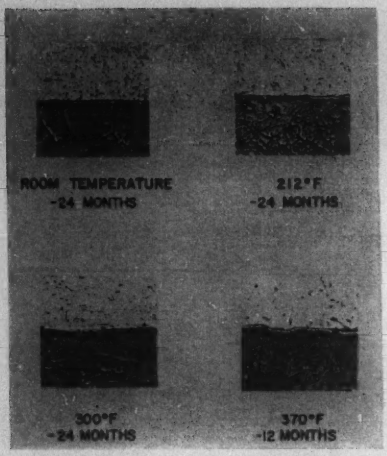


Fig. 10. *(left)* Etched cross sections of joints after heating; 500X—Groups A and B.

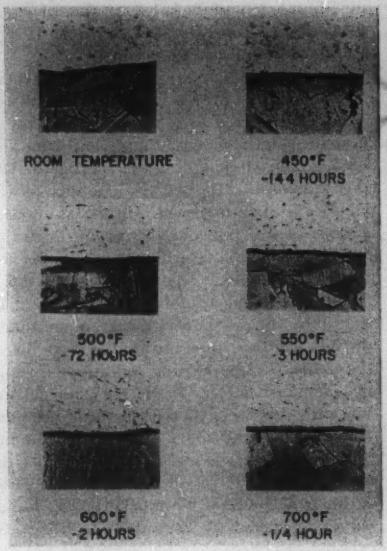


Fig. 11. *(right)* Etched cross sections of joints after heating; 500X—Group C.

that had not been heated, the number of specimens that actually fractured at the welds was so small, and the number of specimens in which the welds withstood the impact blow was so large, that the values themselves are not significant in evaluating the effects of heating.

The measurements of electrical resistance at room temperature after heating for the longest period of time at each temperature are listed in Table III. The data show no trend toward an increase in resistance with increase in temperature or time of heating.

Table III. Electrical Resistance of ¼- by 1½-Inch Flash-Welded Aluminum-Copper Joints

Heating Conditions		Electrical Resistance, Microhms, in Gage Length of	
Temperature (fahrenheit)	Time	4 inch	2 inch
Groups A and B			
	(Months)		
RT		10.0	5.0
212	24	10.1	5.0
300	24	9.9	4.8
370	12*	10.0	
Group C			
	(Hours)		
RT		9.8	4.8
450	144	9.7	4.8
500	72	9.8	5.0
550	3	9.8	4.8
600	2	9.7	4.7
700	¼	9.8	4.8

* Intermittent instead of continuous heating; total time at temperature.

Furthermore, the resistance of a 2-inch gage length was almost exactly half that of a 4-inch gage length. If the thickness of the layer of intermetallic compound had been increased by the heating, the resistances would have increased and the resistances for a 2-inch gage length would have been more than half of those for a 4-inch gage length. This would also be the case if any discontinuities, such as separation at the intermetallic layer, had been caused by heating.

Photomicrographs of welds subjected to each of the temperatures for the longest periods are shown in Figs. 10 and 11. There is little if any significant increase in thickness of the interfacial layer with increase in temperature or length of heating period. The thickness of this layer generally was 0.00015 inch or less.

SUMMARY AND CONCLUSIONS

Improved techniques have been developed by which flash-welded joints between aluminum and copper can now be made commercially. The average strengths of the welds are at least 10,000 psi when heated as high as 300 F for 2 years, 370 F for 1 year, 450 F for 144 hours, 500 F for 36 hours, 600 F for 2 hours or 700 F for 5 minutes. The strengths of individual welds, however, may drop below 10,000 psi when joints are heated 48 hours or more at 500 F, or when heated for shorter times above that temperature.

There was no evidence of embrittlement at any of the heating conditions used.

REFERENCE

1. Preventing Embrittlement in Copper-to-Aluminum Weld Joints, G. L. Carlson, R. M. Leedy. Product Engineering, New York, N.Y. Oct. 1955, pp. 172-73.

Induction Motors with Permanent Magnet Excitation

J. F. H. DOUGLAS
FELLOW AIEE

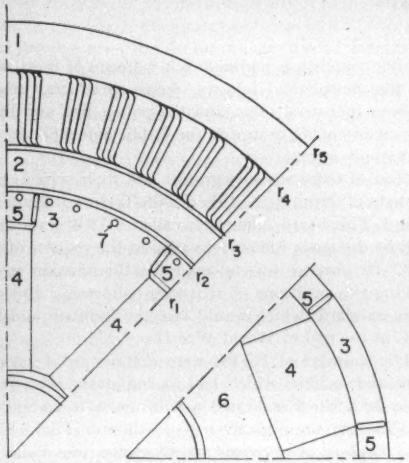


Fig. 1. Induction motor, 8 poles, 60 cycles, 10 hp, with permanent magnet excitation. (1) Primary member, (2) secondary member, (3) magnet member, (4) barium ferrite, (5) leakage path, (6) steel, (7) cage to accelerate magnet member. Insert is alternative form with Alnico VI.

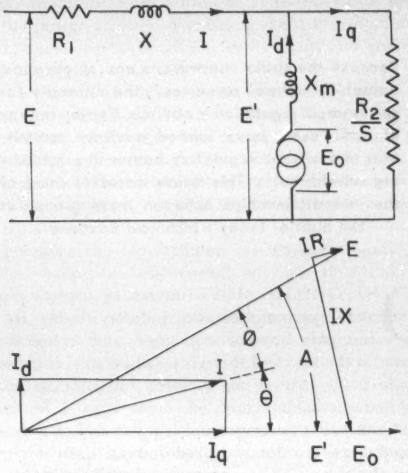


Fig. 2. Equivalent circuit and phasor diagram for motor with permanent magnets. I_d and I_q are components of current. R_1, R_2, and X are usual induction motor constants. X_m is reactance in magnetizing circuit. E_0 is the counter emf in magnetizing circuit.

INDUCTION MOTORS have been built in Germany with a free running member carrying d-c excitation. They had excellent characteristics, including 100% power factor. Permanent magnets have been substituted for d-c excited poles in magnetos and in synchronous motors with good results. Why not, one may ask, substitute them for the d-c free running member of the German motor? Assuming this could be done, a design for an 8-pole 10-hp 60-cycle motor, based on the German motor, was made, its equivalent circuit analyzed, and its performance computed.

The construction assumed is shown in Fig. 1. The primary marked 1 is on the stator; the secondary marked 2 is a cage, and keyed to the shaft by end plates; the magnet member marked 3 is made of steel, with inserted wafers of oriented barium ferrite marked 4. The leakage path, 5, is added for stability. This member is free running at synchronous speed, on the shaft, inside the secondary member.

The equivalent electric circuit was found to be that in Fig. 2. The chief difference between this circuit and that usually used for an induction motor is the presence of a back electromotive force in the magnetizing circuit. Using calculated constants, the current locus was found to be nearly a circle and the power factor between 98% and 100% up to full load. Typical current, slip, and torque loci computed are shown in Fig. 3.

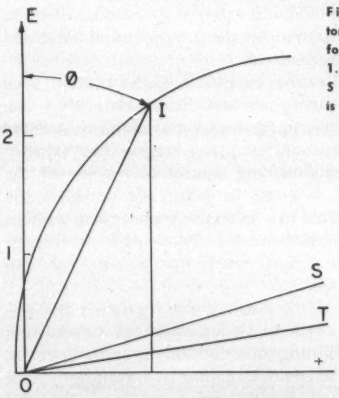


Fig. 3. Current, torque, and slip loci for the motor of Fig. 1. *I* is current locus, *S* is slip locus, and *T* is torque locus.

Digest of paper 59-1, "Characteristics of Induction Motors with Permanent Magnet Excitation," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 1-6, 1959. Published in AIEE *Power Apparatus and Systems*, June 1959, pp. 221-25

J. F. H. Douglas is with Marquette University, Milwaukee, Wis.

Utilities Radio Regulation and Technical Advances

J. C. SLOTHOWER
MEMBER AIEE

Because the radio spectrum is one of our most valuable "natural resources," the necessity for government regulation is obvious. Certain groups of radio users have formed advisory committees to assist the regulatory bodies in establishing suitable rules. This article discusses some of the interrelationships between these groups in the light of today's technical advances.

ONE OF THE MOST interesting aspects of the radio communications industry today is the interplay between regulation and technical advances in the art. And there is no phase of this industry in which the two are more closely related than in the mobile radio field.

The fact that governmental regulation and technical advances are so closely linked follows quite logically from the nature of the medium which is utilized—the radio spectrum. There can be little question that it is one of our most valuable "natural resources," although one which, as has often been pointed out, can be used without being used up. In fact its value is a direct function of the extent to which it *is* used. This usefulness, in turn, is in general a function of the amount of traffic which can be carried or the amount of information which can be transmitted.

There are, of course, exceptions to this concept, such as the various emergency and distress channels whose principal value lies in their instant availability. A heavy traffic load here would completely negate their value.

Without regulation and control of the use of the radio spectrum, it would be practically worthless and might be compared to a vehicular traffic system without any rules or regulations—the fellow with the biggest truck and loudest horn would be the only one who could get through.

It is to the end of assisting the regulatory bodies—specifically, the Federal Communications Commission (FCC)—in establishing suitable rules or "traffic laws," to use the vehicular analogy again, that certain groups of radio users formed advisory groups such as the National Committee for Utilities Radio (NCUR).

This particular committee represents the electric, gas, water, and steam utilities who are eligible for mobile radio licenses under Part 11 of the FCC rules. Other similar committees represent other groups of users, such as the petroleum industry, forest products, miscellaneous industrial users, and the police, fire, and highway maintenance groups in the Public Safety Service, to name only a few.

Most of these advisory groups had their start as outgrowths of committees of the Radio Technical Planning Board. This board, commonly called RTPB, was organized by the radio industry in 1942 at the request of the FCC. Its purpose was to assist the Commission in resolving the problems of frequency allocation and systems standards which would face the industry and the FCC at the end of World War II.

The sponsors of RTPB were the nonprofit associations and societies which had an important interest in radio and which indicated a willingness to co-operate in achieving the objectives of the Board. The RTPB was composed of 13 panels and 68 committees. Panel 13 represented the mobile and emergency services and Committee 4 of Panel 13 represented the Power Utilities. Committee 1 was the police; Committee 2, fire; Committee 3, forestry and conservation; and so forth.

The NCUR developed from Committee 4 of Panel 13. It serves a dual purpose. One of these purposes, which is also common to many of the other associations or organizations of radio users, is the recommending to the FCC of frequencies which may be used in a given area. These groups have all developed various frequency assignment patterns and plans which are intended to make the most efficient use of the spectrum space and channels which are assigned to it. A detailed account of the frequency assignment plan used by NCUR is given in the Appendix.

The second function of NCUR and the other similar groups is to inform the licensees in the industries involved of various technical and regulatory matters which may affect their use of the radio. It in turn advises and works with the regulatory bodies, in particular the FCC, in developing changes in the rules which may be necessary to aid the efficient utilization of radio by the user groups.

This last item may be made necessary by technical advances or it may come about because of changing operating needs and the changing of the uses to which the licensees may wish to put their radio equipment.

An excellent example of the way in which these various user organizations, again referring in particular to NCUR, operate is given in the matter of reducing the assigned or permitted bandwidths for mobile use or, as it is commonly called, "channel splitting."

Essentially full text of conference paper CP59-1088, presented at the AIEE Fall General Meeting, Chicago, Ill., Oct. 11-16, 1959. Recommended for publication by the AIEE Radio Communication Systems Committee.

J. C. Slothower is with the Northern States Power Company, Minneapolis, Minn.

The needs of the various services including those of the utilities in the Power Radio Service dictated a number of years ago that many additional channels would be needed. In fact, it was recognized in the original 1947 hearings that the assignments made at that time would probably be inadequate for the anticipated growth.

Prior to 1930 the power utilities' use of radio was confined to the special emergency frequencies and was limited by the rules applicable to the special emergency service to the actual duration of emergencies. During the 1930's the electrical industry appeared before the FCC and requested the allocation of a number of channels for their exclusive use. The request was not granted but additional channels were made available to the special emergency service and, thus, were made available on a shared basis with 15 other classes of users to the power utilities. As may well be imagined, the restrictive rules of the special emergency service retarded development, and by 1944 the power utilities were operating only 55 systems with less than 1,000 transmitters. This compares with the 2,000 systems and 135,000 transmitters operating today.

Here is an excellent example of restrictions by a regulatory body which hampered rather than helped development. There was no incentive for the manufacturers or any other group to make active technical development, inasmuch as the severely limited use to which radio could be put would not warrant the expense in most cases.

It should be noted, however, in all fairness to the regulatory bodies, that even if the rules had provided for more extensive use of the radio spectrum by industries such as the utilities, the equipment available and the then-existing state of the art would not, in general, have made the use of radio immediately practicable. However, it *would* have stimulated development.

As the art advanced and as higher and higher frequencies came within the realm of practicality insofar as mobile equipment was concerned, and with the accompanying lowering of cost of equipment, more and more utilities turned to mobile radio as one of the only possible ways in which their operating costs could be held down in the face of rising material and labor costs. This justification did not even take into consideration the safety of life and property which was often completely dependent upon the use of such radio systems.

To return to the matter of split channels, one of the functions of Committee 4, Panel 13 of the RTPB was to make a survey in 1944 of what the utilities industry felt would be their requirements when and if radio channels and equipment became available after World War II. Based upon this survey, the committee developed well-supported estimates of channel requirements. These estimates made it evident at an early stage that no compromise solution would be reached because the demand for channels far exceeded the total supply, with no allowance for government needs, which at the time were unknown because of war restrictions on data of this nature.

The FCC recognized the failure of RTPB to resolve this obviously impossible situation. The Commission started hearings in 1944 and in 1945 issued the Allocation Report creating the various services which now exist, including the Industrial and Special Services Section which includes the Power Service. After a rather lengthy procedure and controversy, finally settled in 1947, an allocation of a total of 31 channels was made to the power utilities. A rearrangement of assignments and general reallocation was made again and resulted in 8 additional channels.

It is in such allocations and rule-making proceedings that regulatory bodies such as the FCC must exercise the wisdom of Solomon and the patience of Job. They must select tolerances and bandwidths which will provide the most channels and best service for users and yet which are within the realm of practicality for commercially available equipment.

To make the requirements too stringent would, in effect, hamstring and curtail the use of radio, because equipment would be too expensive, if available at all. On the other hand, to make requirements too loose would be equally unsatisfactory. In such a case, technical advances which might normally be expected would soon make obsolete the then-available equipment. Wise users would be reluctant to purchase such equipment knowing that technical advances and more stringent regulations would soon reduce the value and usefulness of their equipment.

Thus, the dilemma presented to the regulatory bodies: to make requirements as stringent as possible, limiting present use and its value but forcing technical developments and increasing the future value of the present assignments, or to make equipment requirements "soft" and within the capabilities of commercially available equipment, increasing the present and decreasing the future value of the spectrum.

A "dilemma" is defined by Webster as, "A situation involving the choice between equally unsatisfactory alternatives," or, "An argument presenting an antagonist with two or more alternatives equally conclusive against him whichever he chooses." A more accurate description of the position of the FCC in the establishment of technical requirements and standards could not be written. The Commission was bound to be criticized no matter which path it took.

Fortunately all three parties at interest in the 1947 hearings—the mobile radio users, the FCC and the manufacturers—realized that the equipment standards established were of an interim nature, and proceeded to anticipate and work towards even more refined equipment capable of upgrading and increasing the value of the usable spectrum by allowing more traffic or information to be carried in the same amount of spectrum space. This, in essence, is the purpose of the so-called "channel splitting."

The manufacturers proceeded with the development of more refined equipment capable of operating in narrower channels and the user groups undertook the task of informing their members of the anticipated growth

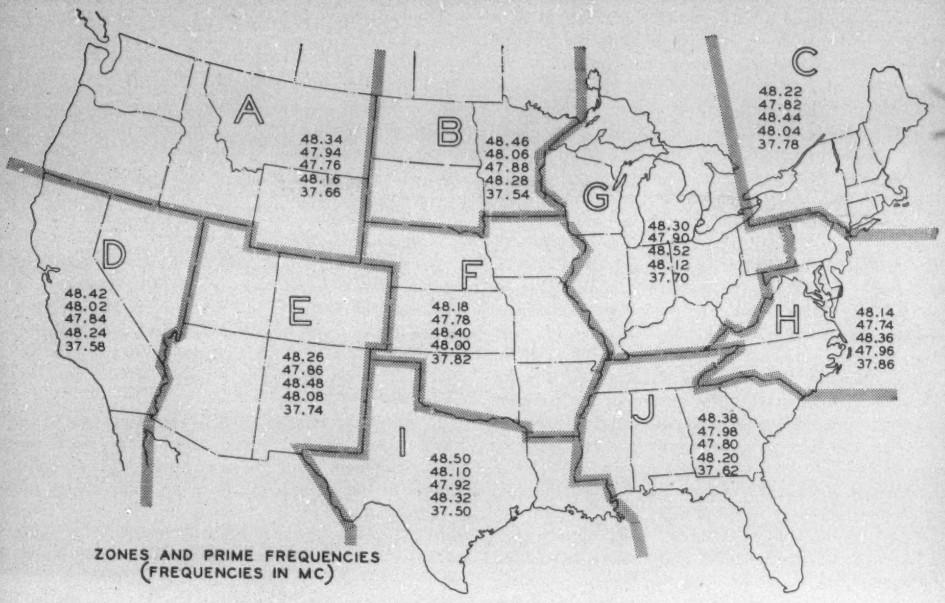


Fig. 1. Frequency assignment plan used by the National Committee for Utilities Radio.

and the complications and changes which might result therefrom.

Consequently, as soon as the manufacturers made it available, many users began to buy equipment capable of operating on reduced channel widths. NCUR itself went on record in 1953 as urging the FCC to proceed with the rule-making proceedings which would make the narrower bandwidths available to the users. This was less than 5 years after the channel assignments using the 40-kv bandwidth and the 30- to 50-mc band and the 60 channel separations in the 150- to 160-mc band had been made.

There was a considerable amount of protest from those who could not see the immediate need for additional channels nor the disastrous consequences which would result from delaying too long before tightening up the technical requirements. It was felt by NCUR and other user groups, as well as the FCC, that the usefulness of the mobile radio would be seriously limited if more channels were not made available within a reasonable length of time.

Here was an excellent example of the "leap frogging" of regulation and technical advances. In this particular case, the narrow-band equipment was available at a reasonable cost before the regulations were changed to require it. However, for the regulatory body to have acted sooner would have made a great deal of equipment technically obsolete unnecessarily soon.

The manufacturers of equipment also agreed generally with the idea of splitting channels, but the suggested technical requirements which they proposed varied widely. The rule-making which finally resulted set up technical requirements as to frequency stability, bandwidths, modulation deviation, etc., which were, in general, as stringent as the most stringent requirements proposed by any of the manufacturers.

Here was an excellent example of "needling" or the providing of an incentive for the manufacturers by the regulatory body. It would have been pointless, of course, for the FCC to set up requirements which could not be met, since this would merely stifle further development and the expanded use of the radio spectrum.

The further progress of the various split-channel dockets will not be traced here, but it is enough to say that it illustrates very clearly the interdependence of technical advances and regulation.

Still another very obvious example of this interplay has been the progression of higher and higher frequencies from the experimental through the developmental and into the "regular" status.

For instance, the 450-mc range was considered strictly experimental only a few years ago, insofar as mobile use is concerned, but it has now progressed through the developmental status and is now in great demand on a regularly assigned basis. Making such frequencies available on a developmental basis served as a stimulus to the manufacturers to develop equipment which could be made commercially available.

Here again the dilemma presents itself to the regulatory agency: should it keep the portion of the spectrum

Table I. Table of Frequencies

	Zones or Regions									
	A	B	C	D	E	F	G	H	I	J
	Order of Preference — Top to Bottom									
	47.76	47.88	48.44	47.84	48.48	48.40	48.52	48.36	47.92	47.80
	48.16	48.28	48.04	48.24	48.08	48.00	48.12	47.96	48.32	48.20
1	48.34	48.46	48.22	48.42	48.26	48.18	48.30	48.14	48.50	48.38
	47.94	48.06	47.82	48.02	47.86	47.78	47.90	47.74	48.10	47.98
	37.66	37.54	37.78	37.58	37.74	37.82	37.70	37.86	37.50	37.62
	48.08	48.00	47.96	48.08	48.24	48.32	47.96	48.04	48.00	47.96
	48.48	48.40	48.34	48.48	48.16	48.28	48.00	48.44	48.40	48.36
2	47.86	47.78	47.74	47.86	48.02	48.10	47.74	47.82	47.78	47.74
	48.26	48.18	48.14	48.26	47.94	48.06	47.78	48.22	48.18	48.14
	37.74	37.82	37.86	37.74	37.66	37.54	37.86	47.78	37.82	37.86
	48.28	48.16	48.12	48.16	47.84	47.92	48.36	48.12	48.08	48.00
	47.88	47.76	48.52	47.76	47.76	47.88	48.40	48.52	48.48	48.40
3	48.06	47.94	47.90	47.94	48.42	48.50	48.14	47.90	47.86	47.78
	48.46	48.34	48.30	48.34	48.34	48.46	48.18	48.30	48.26	48.18
	37.54	37.66	37.70	37.66	37.58	37.50	37.82	37.70	37.74	37.50
	48.24	48.08	48.20	48.28	48.32	48.12	48.28	48.20	48.20	48.32
	47.84	48.48	47.80	47.88	47.92	48.52	47.88	47.80	47.80	47.92
4	48.02	47.86	47.98	48.06	48.10	47.90	48.06	47.98	47.98	48.10
	48.42	48.26	48.38	48.46	48.50	48.30	48.46	48.38	48.30	48.50
	37.58	37.74	37.54	37.54	37.50	37.70	37.54	37.62	37.62	37.82
	48.00	48.12	48.28	48.32	48.28	48.20	48.04	48.00	48.28	48.12
	48.40	48.52	47.88	47.92	47.88	47.80	48.44	48.40	47.88	48.52
5	47.78	47.90	48.06	48.10	48.06	47.98	47.82	47.78	48.06	47.90
	48.18	48.30	48.46	48.50	48.46	48.38	48.22	48.18	48.46	48.30
	37.82	37.70	37.74	37.86	37.54	37.62	37.78	37.82	37.54	37.70

in question on a developmental basis, thus stimulating technical advance yet giving adequate warning to potential users that equipment obsolescence will be rapid as better and more refined equipment is developed? This course of action certainly decreases the present value and hinders the usefulness of the band since prudent users will tend to wait for a stabilizing or some sort of standardizing of equipment. Yet the alternative—adoption of too stringent standards and putting the band on a regular basis too soon—would serve as a major obstacle to further technical advances and thus limit the future value.

Exactly the same sort of question now presents itself to the FCC with regard to the use of frequencies around 900 mc for mobile use.

Such questions and dilemmas also present themselves to the users of mobile equipment, the manufacturers, and the regulatory agencies with regard to many other facets of the mobile radio field. The development of facsimile equipment for mobile use, for instance, and still greater spectrum utilization through measures other than the mere reduction of channel width and modulation. One of the more widely publicized of these other measures is single-side-band equipment. But still others may be in the offing, such as time-division multiplexing for mobile systems or, as has been suggested, a form of modulation operating at right angles to both the electrostatic and electromagnetic lines of force of the radiated field! Fanciful? Probably, but it may be safely assumed that the regulatory agency involved will continue to help break the trail while sitting firmly astride the horns of its ever-faithful dilemma.

Appendix

The frequency assignment plan now used by the NCUR in its recommendations was developed in 1947 by George Underhill and was used unchanged until 1958 when it was modified somewhat to take into account the newly authorized "splits."

The Underhill Plan is based upon the simple theory that, within rather indefinite limits and with considerable variation in rate of change, the amount of interference, as measured by the ratio of hours during which interference may be experienced to total hours, which may be expected to result from sporadic E and F layer refractions, increases as the distance between a receiver and an offending transmitter increases. It follows that if the total number of transmitters on a single channel can be so distributed geographically as to be a maximum within a definite base area and to gradually decrease in density and in total number as the distance from that base area increases, a condition tending to counteract the increase in interference will result.

In operation, the Underhill Plan assigns certain "prime" frequencies to each of 10 regions, each region being one of the "base areas" described in the foregoing. These frequencies may be used in any combination within the region, but other regions may assign them only as they occur in the priority or sequence list. Fig. 1 shows a map of the regions and Table I gives the sequence lists. The position on the sequence list for each frequency for each region is based upon the likelihood of "skip" or sky-wave interference in that region from the region in which the frequency in question is a "prime" frequency.

For example it will be noted that the second choices for frequency assignments in Region A are the prime frequencies of Region E. This is because Regions A and E are situated geographically so that skip interference is a minimum between them.

Conversely, the fifth choice for Region A is the set of frequencies assigned as prime frequencies to Region F since these two regions are located so that the possibility of skip between them is greater than, for instance, Regions A and E. (It should be noted that only half the table of frequencies used by NCUR is shown in Table I, choices 6 through 10 for each region or zone being omitted for the sake of clarity.)

All-Aluminum Connectors

Huge all-aluminum flexible connectors for an 11,000-ampere 19-inch-diameter tubular aluminum bus have been produced by the Delta-Star Electric Division, H. K. Porter Company, Inc. Each unit measures 28 inches in length and 28 inches across the two terminal taps. Welded construction, except for transformer lead connections, is used to provide a minimum of current interchange surfaces.

In order to facilitate field installation, the units are supplied with a short section of aluminum bus welded into the connectors. This allows a simple tube-to-tube butt weld to be made in the field.

A New Electrical Research Laboratory

F. E. ANDREWS
FELLOW AIEE

ALEX VITKUS
MEMBER AIEE

The research laboratory described is a comprehensive facility, capable of duplicating system operating conditions. Its principal function is the development and engineering of electrical and line construction products for power transmission and distribution systems.

THE POSTWAR DEVELOPMENT of electric power systems has been characterized by increasingly severe requirements of electric apparatus in terms of large short-circuit currents and high voltages. To fulfill the industry's needs for improved equipment to meet these new requirements, and to provide facilities for general research and testing in this field,

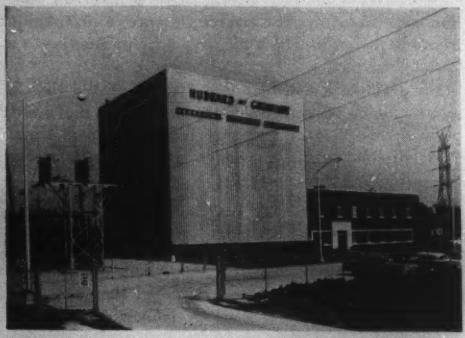


Fig. 1. Over-all view of laboratory.

Hubbard and Company placed in operation during 1958 a new electrical research laboratory at McCook, Ill., near Chicago. This laboratory is a fully integrated facility, capable of duplicating system operating conditions, where both electrical and line construction products for power transmission and distribution systems and for wire communication systems can be developed from the inception of ideas to fully tested production items. Among the more important features are the power laboratory, the impulse and high-voltage laboratory, model shop, and indoor and outdoor mechanical laboratories. Fig. 1 shows an over-all view of the laboratory. Its general plan and size are shown in Fig. 2.

The 63- by 68-foot high bay portion of the laboratory building houses the high-voltage equipment and most of the other electrical test equipment not in the power laboratory. Its height, 57 feet to the roof trusses, was determined by the 24-foot clearance required from the top of the high-voltage surge generator.

POWER LABORATORY

THE POWER LABORATORY is shown at the left of both Figs. 1 and 2. It duplicates power system operating voltage and current conditions, especially with respect to short-circuit testing of protective devices. The principal elements and connections are shown in Fig. 3.

Test energy supply is at 138 kv single phase line to line, from a short radial circuit originating at a major transmission substation of the local utility. High-capacity transmission lines from several principal generating sources converge at this substation.

Transformation to test voltages is provided by a Class OA 2-winding transformer designed for an intermittent maximum short-circuit duty cycle of six 12-cycle tests per hour. Voltage rating is 138/18 kv through 1.5 kv in 1.5-kv increments, with each of the low voltages obtained through selective use of taps brought out through 10 roof bushings. Connections from these low-voltage bushings to the main test bus are completed through selector disconnect switches which can be closed in the proper combinations to provide the test voltages and capacities desired. The low-voltage winding consists of two 9-kv sections which can be used singly or in parallel for voltages of 9 kv and less to obtain two ranges of capacity and impedance. The two sections in series provide voltages between 9 kv and 18 kv. The transformer is capable of delivering 254,000 kva asymmetrical, from an infinite bus.

Adjustments of test current, power factor, and recovery voltage are accomplished in the circuit-adjustment bay, shown in Fig. 4, by connecting appropriate reactors, resistors, and capacitors into the circuit ahead of the test specimen. A number of transformers also are employed to obtain voltages and currents outside the range obtainable directly from the main transformer. For this purpose, the following major transformers are being added to the power laboratory:

1. A series regulating transformer on the load side of the main transformer to provide voltage steps as low as 0.33 per cent above or below the main transformer output voltages.

Condensation of paper 59-60, recommended by the AIEE Protective Devices Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N.Y., Feb. 1-6, 1959. Published in AIEE *Power Apparatus and Systems*, Aug. 1959, pp. 489-98.

F. E. Andrews and Alex Vitkus are with Hubbard and Company, McCook, Ill.

The authors wish to acknowledge the work of Dr. C. S. Sprague in the design, development, and construction of the 3,000,000-volt and the 80-kilowatt-second high-current surge generators described in this article. These generators were originally built under his direction at Purdue University.[3]

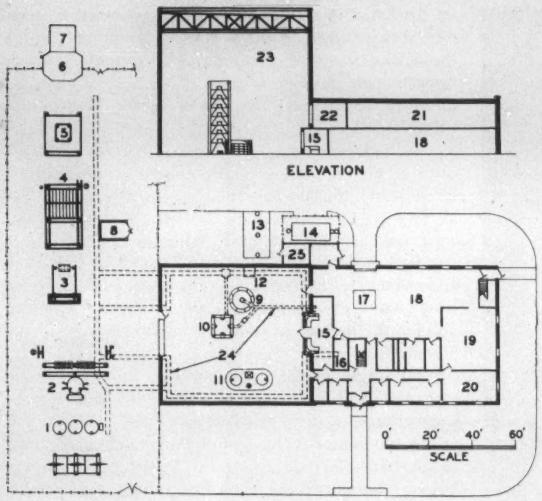


Fig. 2 (left). Plan of laboratory.

1–138-kv oil circuit breaker
2–Main test transformer
3–Overcurrent protection bay
4–Impedance and transformer bays for circuit adjustment
5–Test bay
6–Safety viewing room
7–Test cell
8–Initiating surge generator
9–High-current surge generator
10–High-voltage surge generator
11–600-kv 60-cycle test set
12–Power laboratory cable terminal
13–Distribution-equipment life test structure
14–4-kv transformer station
15–Control room and master console
16–Photographic laboratory
17–Universal mechanical testing machines
18–Model shop
19–Insulating materials laboratory
20–Analytical laboratory
21–Offices and drafting room
22–Conference room, library, and high bay laboratory observation room
23–High bay laboratory
24–Wiring trenches
25–D-c battery room

2. A high-current low-voltage transformer to provide short-time test currents as high as 200,000 amperes rms for 4 seconds.

3. An auto-transformer, 18/27-36 kv, to provide full power laboratory capacity at voltages between 18 and 36 kv.

The test specimen may be located in either the outdoor barricaded test bay or the enclosed test cell shown in Fig. 5. The latter is a reinforced-concrete impact-resistant fireproof structure, suitable for testing oil-filled or other equipment for additional safety in case of an oil fire or flying parts. An overhead line extends beyond the test cell. This may be energized from the test bus, and is useful for testing varied construction and equipment under actual line operating conditions.

Primary overcurrent protection is provided by the 138-kv oil circuit breaker and its overcurrent induction relays. Power fuses or expulsion fuse cutouts, used according to duty required for the particular tests, provide overcurrent protection for normal testing, with back-up protection by the low-voltage oil circuit breaker and its relays.

Power laboratory test operations for overcurrent protective equipment tests are normally initiated by firing a small surge generator to sparkover the initiating gap in the test circuit. For combined power and surge-current testing, as for lightning arresters, the test is initiated by applying the test surge directly to the test specimen. The test is precisely initiated at any selected

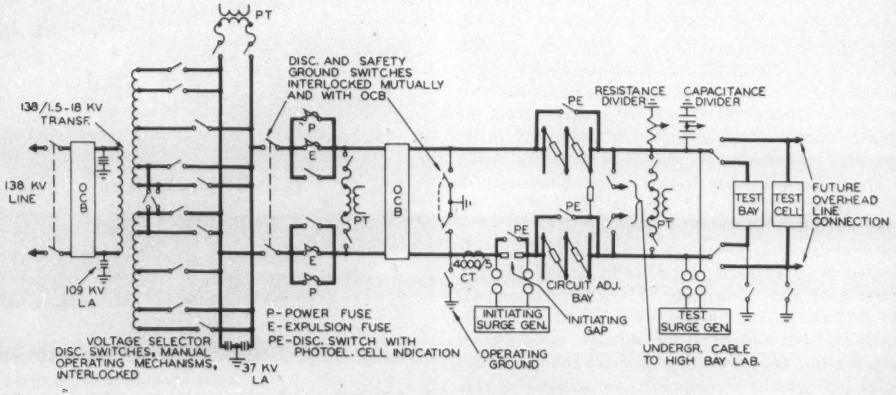


Fig. 3. Power laboratory connection diagram.

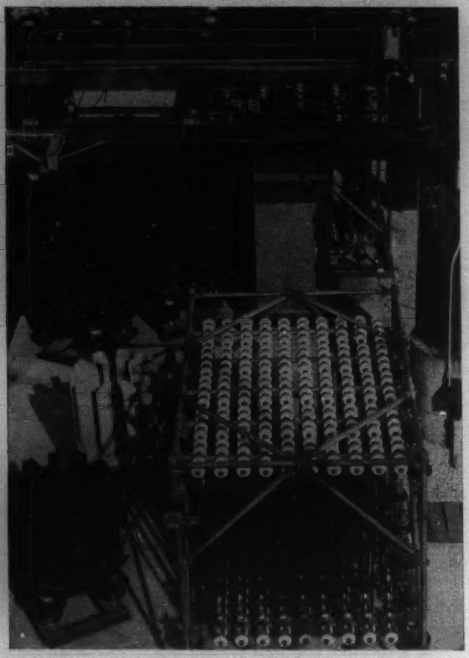


Fig. 4. Impedance section of circuit-adjustment bay.

point on the 60-cycle voltage wave by a synchronously rotating device which triggers the surge generator. Rotating the synchronous motor frame adjusts the firing angle and produces a predetermined condition of short-circuit current asymmetry.

SURGE GENERATORS

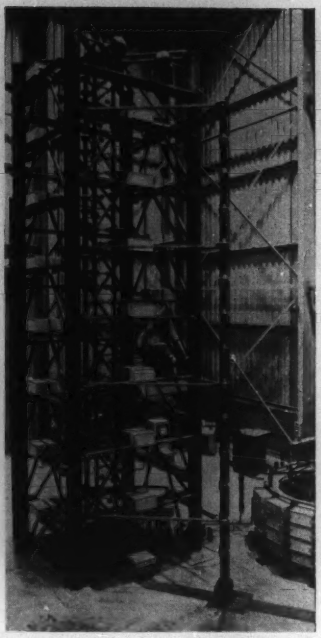
THE HIGH-VOLTAGE surge generator[1] shown in Fig. 6, has maximum ratings of 3,150 kv and 40 kilowatt-seconds. Taps divide the generator into sections to provide lower voltages. Practical maximum output voltage is 2,450 kv for the 1½x40-microsecond wave for which the generator is normally arranged. Crest voltages of 950 kv and 350 kv are available from the tapped sections. The generator is comprised of 32 capacitors connected in the special Marx circuit shown in Fig. 7. Its distinctive feature is the elimination of interstage resistors usually used in the conventional Marx circuit. This provides more effective charging and reduces energy losses during discharge. It is made possible by mechanical switching of charge and discharge gaps and connections. The charging contacts and discharge gaps are mounted on four vertical shafts extending from bottom to top through the center of the generator. They are rotated between charge and discharge positions by a compressed air actuator to connect the capacitors in parallel for charge and in series for discharge. A column of capacitors shunted by resistors, seen in front of the generator, assists in shaping the output wave, serves as a divider for voltage measurement, and provides tap-off points for test voltages intermediate between the three established output voltages.

The high-current surge generator, shown schematically in Fig. 7, has maximum ratings of 80 kilowatt-seconds and 150,000 and 300,000 amperes crest at 100 kv and 50 kv, respectively. Practical output current crest with circuit constants adjusted to produce a standard 10x20-microsecond current wave at 100 kv is approximately 100,000 amperes. The connecting bus work and test specimen are located in the center to provide the lowest impedance.

Deflection pulses from the high-voltage and high-current surge generators are brought into the control room for instrumentation, by coaxial cables in copper-lined troughs.

The laboratory also has three other surge generators, all portable, for use either inside or outside in the power laboratory. Their voltage ratings are 500 kv, 250 kv, and 125 kv. Each can be operated either from an individual console at the site where located, or from the master control console. They can be used separately or combined and co-ordinated with the larger

Fig. 5. Enclosed test cell and outdoor test area. Safety viewing room is at rear of test cell.



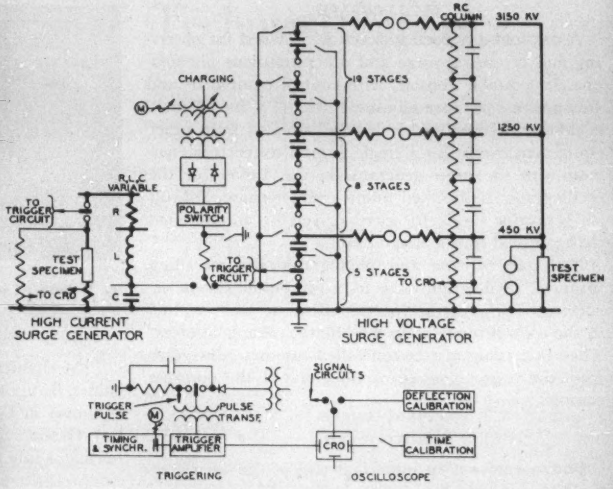


Fig. 6 (left). High-voltage surge generator. Fig. 7 (above). Simplified circuit diagram of main surge generators.

surge generators for investigation of multiple-surge phenomena and surge and power follow investigation. For such work, 60-cycle power is available inside through an underground cable connection from the power laboratory.

CONTROL AND INSTRUMENTATION

CONTROL AND INSTRUMENTATION for the entire laboratory are centered in the master control console, in a room with windows overlooking the high bay laboratory. Twelve main panels cover the full range of test operations. Fig. 8 shows the right-hand section of the main console. Each panel is equipped with meters and devices to implement the control and operating function for which it is intended and to give readings of all electrical or other relationships applicable to that function.

The two power laboratory panels include the usual oil circuit breaker controls, voltmeters, and ammeters. They also have mimic busses and solenoid-operated mimic switches to represent disconnect switches. A dial switch associated with a system of indicating lights and operating mechanism interlocks assures correct operation of the test transformer voltage-selector disconnects. Certain of the disconnect switches have photoelectric relays operated from targets on the switchblades to indicate, at the console panel, the switch position.

To provide personnel safety, the power laboratory test initiation circuit is completed through interlocks on the yard gates and finally through a foot switch in the test area viewing room. This permits the test monitor to stop a test if the power laboratory yard is not clear of personnel or if other questionable conditions develop. A reversible loudspeaker–microphone arrangement provides continuous communication between the control console operator, the yard area, and the test viewing room.

Fig. 8. Master control console, right-hand section. Oscillograph console is at right.

Console panels are provided for each of the several surge generators and the two 60-cycle high-voltage test sets. A wet-flashover test panel monitors water precipitation rate, conductivity, and pressures.

The console provides complete automatic timing and sequencing of test operations for both power and surge laboratories. This includes charging and triggering of surge generators, starting and stopping of oscillographs and motion-picture cameras, and test initiation. A sequence may be started by push button control or it may be set up for automatic repetitive starting.

OSCILLOGRAPHY

A CATHODE-RAY OSCILLOGRAPH is provided for observing and recording surge and other transient phenomena. Its portable console, with control equipment and instruments, is normally used inside a metal mesh enclosure electrically shielded and isolated from other equipment except for a single ground connection common with the surge generator in use. Power for the oscillograph is supplied from a single-phase 120-volt a-c generator inside the cage, driven by an insulated shaft coupled to a motor outside.

Both pen writing and photographically recording magnetic oscillographs are used for power system recording. They can be located either at the test site, in the control room, or in the photographic laboratory. Their operations may be controlled automatically either from the master console or from one of the portable consoles.

PHOTOGRAPHY

PHOTOGRAPHY is an important tool of the laboratory for both analytical and record work. Ultrahigh-speed motion-picture photography is used extensively. For this, a rotating-prism camera with speeds up to 8,000 frames per second is employed. To provide adequate lighting for the short exposure associated with such high speed, a recently developed high-intensity xenon quartz bulb lamp is used. The camera and lamp have a co-ordinated timing control tied in with the control console so that their operations are properly timed and integrated with the entire test operation.

Conventional still and motion-picture cameras are used widely. A photographic laboratory is provided for on the job processing and for general photofinishing.

With these facilities, it is possible to carry on practically any type of photography and to reduce to slow motion such extremely fast movement as occurs with circuit breaker or fuse cutout mechanisms subjected to forces associated with electric arc extinction.

OTHER FACILITIES

A NUMBER OF OTHER FACILITIES round out ability of the laboratory to conduct the wide variety of work required for development, engineering, and testing of products for power and communication utilities. Installation of some of these is still in progress. Among the more important of such facilities are the following:

1. Power-frequency high-voltage test sets with maximum voltages of 600 kv and 100 kv.
2. Portable consoles for control and instrumentation at the test site.
3. Wet-flashover test equipment.
4. Heat-run test equipment, complete with current supply, portable console, and automatic temperature recorder, to provide continuous currents up to a maximum of 40,000 amperes.
5. Insulating materials laboratory.
6. Analytical laboratory for physical and chemical testing.

Fig. 9. Universal testing machine. Deflectometer is at left and graphic recorder at right.

7. Mechanical laboratory with universal testing machines, equipped with load-deflection graphic recorders, as shown in Fig. 9.
8. Outdoor mechanical test installation for full-scale testing of line hardware and structures.

REFERENCE

1. Design of a Three Million Volt Impulse Generator, N. W. Richards. *M. S. Thesis*. Purdue University, Lafayette, Ind., June 1950.

Giant "Four-Leaf Clover"

Appearing as a giant four-leaf clover is one of the two propellers that will drive the cruiser *U. S. S. Long Beach*, the Navy's first atomic-powered surface ship. The two reactor plants were designed and developed by Westinghouse Electric Corporation for the Naval Reactors Branch, U. S. Atomic Energy Commission. Bethlehem Shipbuilding Division of Bethlehem Steel Company is the designer and builder of the guided-missile cruiser, which is 721 feet long.

Abstracts of AIEE Technical Papers

COMMUNICATION DIVISION

59-194. A Design for Using Closed-Circuit Television in Education. *F. E. Almstead.* A closed-circuit cable connects the public schools of one city and two rural systems in Cortland County, N. Y. The unique electronic circuitry was planned by Dage (a Division of Thompson Products), the New York Telephone Company, and the New York State Education Department, with specific operating and educational conditions in mind. Two fully equipped studios, two r-f channels, and adequate distribution systems within each school, including high-quality receivers, were installed. The talk-back system is an important feature in the project. It is hoped that experience with this installation will determine the number of pupils required per mile of cable for an economically feasible operation. Broadcasting began on September 29, 1958. (C&E, Sept. 1959, pp. 439-44.)

GENERAL APPLICATIONS DIVISION

59-247. Improved D-C High-Potential Testing of Insulation Systems in Low- and Medium-Voltage D-C Equipment. *A. M. Odok, T. M. Soelaiman.* Testing of electric apparatus with d-c voltages has been used increasingly in recent years. In order to overcome some of the pitfalls of d-c step voltage testing, it is suggested that discharge detection methods be used to indicate any small charge shifts in the insulation. Such shifts in electric charges occur in increasing proportion as the breakdown voltage is approached, and are due to breakdown of minute conducting paths or ionization. Methods of detection of discharges and their interpretation are illustrated with experimental results. (A&I, Sept. 1959, pp. 186-99.)

59-864. Generator Insulation Systems Development for Hypersonic Aircraft. *W. B. Penn, R. L. Balke, F. M. Precopio.* To comply with a U. S. Air Force contract which called for the development of an aircraft generator to supply electric power to hypersonic aircraft, required the development of an insulation system capable of operating at 500 C. Various materials and systems were investigated. A ground insulation of a flexible flake mica composite with an inorganic binder and a ceramic coating agent for the windings were found satisfactory, using a rigorous testing technique and procedure also developed for this project. (A&I, Sept. 1959, pp. 255-58.)

INDUSTRY DIVISION

58-210. A Recommended Program for Resistance-Welding Instrumentation. *A. Dixon.* Large potential savings in manufacuring cost by standardizing resistance-welding procedures has influenced the united effort of research and manufacturing people within the Westinghouse Electric Corporation to develop a system of instrumentation for the effective implementation of this program. This paper describes the development of acceptable practice based on a study of available instruments and their performance. The cost and simplicity of use at the resistance-welding machine operator level were major considerations. Recommended equipment and methods for machine calibration are discussed and typical work schedule charts illustrated. The system has proved highly practical in more than 7 years of production use. (A&I, Sept. 1959, pp. 199-209.)

REFERENCES which accompany these abstracts are to the current bimonthly publications. Page numbers given will also apply to the corresponding part of AIEE *Transactions*, vol. 78, 1959, when it becomes available in the Spring of 1960.

Part I. Communication and Electronics (C&E)
Part II. Applications and Industry (A&I)
Part III. Power Apparatus and Systems (PA&S)

59-218. A Relay-Type Feedback Control System Designed for Random Inputs. *A. M. Hopkin, P. K. C. Wang.* A method is demonstrated for designing relay-type control systems to be "optimum" for some classes of random inputs. "Optimum" is used in the sense that the system strives to zero the predicted error and its various order derivatives simultaneously in minimum time. Test data involving second-order control systems so designed show excellent performance, provided that a prediction filter can be designed to predict the input signal with moderate accuracy for a reasonable time into the future. (A&I, Sept. 1959, pp. 228-33.)

INSTRUMENTATION DIVISION

59-157. A Magnetic Amplifier Flow Controller. *H. E. Darling.* An all-magnetic amplifier controller is described, intended primarily for fast response (flow) industrial processes, using a 10- to 50-milliampere d-c input and output, and operates from 60-cycle power. A process control signal, in opposition to a continuously adjustable set point signal, is applied to a 2-stage high-gain magnetic amplifier through a proportional-band adjustment. A portion of the output is degeneratively fed back to the input through an *R-C* network to produce resetting action. Proportional bands of 50 to 500%, and reset times of 0.5 to 30.0 seconds per repeat are obtained. Excellent zero stability and frequency response result. (C&E, Sept. 1959, pp. 373-79.)

59-158. An Impedance Bridge for Surface Temperature Measurement. *R. J. Mouly.* The paper presents a special automatic impedance bridge based on a sinusoidal eddy-current technique. The instrument permits the accurate and reproducible noncontacting measurement of the electrical and magnetic properties of a conductive body placed in the immediate vicinity of a sensing probe. The instrument output is insensitive to the probe-to-surface spacing variations. The application of the instrument to the emissivity-free detection of the surface temperature variations of a metallic body is described. (C&E, Sept. 1959, pp. 388-93.)

59-161. A Wide-Range Volt-Ampere Converter for Current and Voltage Measurements. *F. L. Hermach, E. S. Williams.* A "universal" volt-ampere converter has been developed for making current and voltage measurements with an accuracy of 0.05% at frequencies from 5 cycles per second to 50 kc and also on direct current. With this single, self-contained, portable, 44-range instrument, a 1.5-volt d-c null-type potentiometer can be used to make a-c (rms) and d-c measurements from 7.5 milliamperes to 20 amperes and from 0.5 volt to 600 volts. With a more sensitive external galvanometer, the instrument can also be used as an a-c/d-c transfer standard for a-c/d-c difference measurements to 0.02% over the same frequency range. (C&E, Sept. 1959, pp. 384-88.)

POWER DIVISION

59-11. Constant-Excitation Current-Locus Diagrams of Saturated Salient-Pole Synchronous Machines. *S. A. Nasar.* Constant-excitation locus diagrams of a synchronous machine predict the steady-state performance of the machine under a wide range of operation. For ideal machines, where saliency and saturation are ignored, these diagrams are circles. However, for salient-pole saturated machines the diagrams deviate from being circular. The extent of deviation for a fixed excitation can be represented and compared on the locus diagrams. These diagrams for salient-pole machines may be drawn by using the 2-reaction theory. The effects of saturation can be included by using the numerical value of reactance corrected for saturation. (PA&S, June 1959, pp. 266-68.)

59-58. Staged Fault Tests with Power-Line Carrier Transferred-Trip Relaying for Line Protection. *D. E. Jones.* Staged fault tests have been carried out on a 230-kv circuit in order to assess the reliability of power line carrier equipment for transferred-trip relaying protection of transmission lines. Arcing faults were applied to a line close to the carrier receiving terminal. It was found that carrier equipment will provide reliable tripping under these conditions at practical carrier power levels. (PA&S, Aug. 1959, pp. 588-95.)

59-60. A New Electrical Research Laboratory. *F. E. Andrews, Alex Vitkus.* The new electrical research laboratory of Hubbard and Company at McCook, Ill. is a comprehensive facility, capable of duplicating operating conditions. Its principal function is the development and engineering of electrical and line construction products for power transmission and distribution systems. Some of the more important features are: the power laboratory, with a wide range of voltages and currents extending into the short-circuit region; the impulse laboratory for high-voltage, high-current, and multiple-surge testing; centralized control and instrumentation, with automation for properly timed sequencing, oscillographic recording, and repetitive operation; power-frequency high-voltage test set; ultrahigh-speed motion-picture photographing equipment; and the mechanical laboratory for full-scale testing of structures and line hardware. (PA&S, Aug. 1959, pp. 489-98).

59-62. Iteration Methods for Digital Load-Flow Studies. *J. E. Van Ness.* In this paper a set of linear equations is developed relating small changes in voltage magnitude and angle with corresponding changes in real and reactive power flow in a power system. Six different iteration methods are examined using these relationships. The different methods were tested experimentally with a 6-node sample problem to find the relative speeds of convergence. The results of this test are given in tabular form both in terms of the number of iterations needed and the time needed per iteration. (PA&S, Aug. 1959, pp. 583-88.)

59-67. The British Columbia Electric Company's 360-Kv and 230-Kv Transmission-Line Design. *L. H. J. Cook.* This paper gives details of two 230-kv steel tower line designs and three 360-kv tower line designs. The tower loadings, insulation, and conductor clearances are discussed in detail, as are the factors of safety, their combination and application. The author points out that over the past 10 years the weight of steel required for both 230- and 360-kv lines has been reduced substantially and that, as the weight of steel is one of the prime factors affecting the cost of line construction, this saving of weight has been reflected in a reduction in over-all costs. These weight savings have been achieved by reducing insulation requirements, the use of longer spans and higher conductor tensions, and a reduction in factors of safety arising out of a more realistic appraisal of tower loadings. The paper concludes with the statement that with the advent of extra-high-voltage transmission, a reassessment of design criteria becomes a necessity if transmission costs are to be kept within acceptable limits. (PA&S, Aug. 1959, pp. 537-45.)

59-80. A Correlation of the Present with a Proposed Standard Method for RIV Measurements on High-Voltage Devices. *C. J. Miller, Jr.* To investigate possible changes in RIV levels on high-voltage devices occasioned by reducing the radio noise meter detector charging time constant from 10 to 1 millisecond and the NEMA circuit impedance from 600 to 150 ohms, RIV correlation tests were made using 17 different specimens including various line insulators, station equipment, conductors, and gaps. Results indicate that the combined effect of both changes produced a negligible change in their RIV levels. Similar tests on 12 different specimens showed that Stoddard and Ferris radio noise meters, both with 1-millisecond time constants, agreed quite well with each other. (PA&S, Aug. 1959, pp. 574-82.)

59-82. Bundled Conductor Voltage Gradient Calculations. *J. Reichman.* Radio interference and corona loss studies on high-voltage transmission lines require a knowledge of voltage gradients which exist at the surface of conductors. This paper covers such calculations for extra-high-voltage lines using 2-, 3-, and 4-conductor bundles. The results are presented in graphical form so that bundled conductor designs, for any specified voltage gradient at line voltages up to 500 kv, can easily be obtained. (PA&S, Aug. 1959, pp. 598-607.)

59-96. Transmission Conductor Vibration Tests. *M. B. Elton, A. R. Hard, A. N. Shealy.* Improved measuring techniques are described with emphasis on results obtained to date from field and laboratory conductor vibration investigations. Experienced use of the Jaquet cycle counter on energized lines has shown it to be an economical aid in providing selective damping at substantial savings.

Results of cyclic strain measurements on an operating 345-kv line are described with curves included showing strain level distribution, correlation with time of day, frequency, and wind. Some results have more than offset the cost of vibration research. (PA&S, Aug. 1959, pp. 528-37.)

59-142. The Establishment of a Base for Class A Random-Wound-Motor Insulation Life by AIEE Standard No. 510 Test Procedure and its Correlation with Field Experience. *R. L. Balke, D. R. Blake.* The AIEE Standard no. *510* Test Procedure has, in general, been well accepted by the electrical industry as an accelerated test method for comparing and predicting life and performance of insulation systems for random-wound electric machinery. This paper presents motor test data, collected by this procedure, comparing the performance and life of a modern Class A insulation system with that of a Class A system used in the industry on small motors since 1941. The modern system provided exceptionally longer life than the system in use since 1941. However, a degree of correlation was shown for extrapolated life of the system in use since 1941 and the actual life demonstrated by this same system in field service. In addition to providing more data to the aggregate now being collected within the industry, and accordingly establishing more confidence in a base insulation life for the AIEE *510* Procedure, these data indicate extrapolation of accelerated test data collected by this method are reasonably accurate for predicting life at normal operating conditions. (PA&S, Aug. 1959, pp. 660-65.)

SCIENCE AND ELECTRONICS DIVISION

59-102. A Theoretical Analysis of the Effects of an Electric Field on the Charging of Fine Particles. *A. T. Murphy, F. T. Adler, G. W. Penney.* The charge imparted to fine (less than 1 micron in diameter) particles is determined by considering the random heat motion of ions in a unipolar discharge. It is shown that the effects of the strong electric field which were neglected in previous analyses are (1) an increased ion energy caused by its motion in the field, and (2) an increased ion density around the particle. The second effect is greatly predominant in molecular ion charging. The magnitude of this effect was determined approximately by digital computer methods. The results show that this effect may almost completely account for the higher charge found experimentally. (C&E, Sept. 1959, pp. 318-26.)

59-145. Effects of Operation of Germanium Alloy Junction Transistors Above Rated Conditions. *B. C. Spradlin.* Twenty each of two similar types of germanium alloy junction transistors were subjected to each of several combinations of ambient temperature and power dissipation in a common emitter circuit for 1,000 hours. Power dissipations employed were 100, 150, and 200 milliwatts in ambient temperatures of 100 C and 120 C for one type, and temperatures of 80 C, 90 C, and 100 C for the other type. Median variations of I_{CBO}, I_{EBO}, h_{fe}, h_{FE}, BV_{CBO}, and V_{FT} with time are presented as curves. Also, estimates of the mean lives (using arbitrary failure criteria) of the transistors operating at the stress conditions of the exploratory experiments are given. (C&E, Sept. 1959, pp. 346-52.)

59-148. Design of a Vertical Magnetic Recording Head with Large-Scale Models. *J. T. Smith.* In the field of magnetic recording, the physical dimensions of the recording heads are very small. As a direct consequence of this, to change one of the parameters in the recording head while holding all other variables constant is a difficult and expensive proposition. This paper describes a method in which large-scale models of recording heads are used to relax the precision of machining required to study the effect of several variables upon the resolution and amplitude of magnetically recorded signals. The technique is applied to the design of a vertical recording head. (C&E, Sept. 1959, pp. 357-62.)

59-206. Field-Strength Measurements in Parallel-Plate Precipitators. *J. S. Lagarias.* The field-strength distribution between simulated parallel-plate precipitator electrodes was determined experimentally for several different geometries. Regions of high field strength were concentrated between wire and plate. In other areas, the field strength was dependent on voltage and current flow. Increasing the discharge electrode wire-to-wire spacing in the range examined resulted in an increase per unit length of discharge electrode. The current per unit plate area was independent of the discharge electrode spacing. The presence of dust loading altered the field strength as it changed the current flow. (C&E, Sept. 1959, pp. 427-33.)

INSTITUTE ACTIVITIES

AIEE Celebrates 75th Anniversary of the Institute's First Technical Meeting

THE DIAMOND ANNIVERSARY of AIEE's first technical meeting, which was held in Philadelphia, Pa., on October 7-8, 1884, at the time of the International Electrical Exposition, was celebrated with a dinner meeting on October 7, 1959. The meeting, held jointly with the Franklin Institute, provided a fit setting, inasmuch as it was the Franklin Institute which planned the International Electrical Exposition of 1884; and also, the first AIEE technical meetings were held in rooms under their auspices. After-dinner addresses were given by L. F. Hickernell, past president of AIEE; J. H. Foote, president of AIEE; Brigadier General David Sarnoff; and Vice-Admiral J. T. Hayward, Deputy Chief of Naval Operations, U.S. Navy. President W. L. LePage of the Franklin Institute welcomed the 550 members and guests, expressed great pleasure at the close association with the AIEE, and introduced those at the head table. R. S. Hewitt, chairman of the Philadelphia Section, displayed "A Tribute to AIEE from the City of Philadelphia" which was signed by Mayor Richardson Dilworth (*Electrical Engineering*, November 1959, p. 1128). Arrangements for the meeting were made by R. L. Halberstadt, vice-chairman of the Philadelphia Section and chairman of the 75th Anniversary Meeting Committee.

During the day, two sessions were held which constituted a classified briefing on the subject, "Oceanography and Its Military Implications," at which presentations were made by seven experts from the Office of the Chief of Naval Operations Research and Development. The luncheon speaker was Dr. I. M. Levitt, director of the Fels Planetarium, whose subject was "Space Travel." More than 400 guests from various parts of the United States attended the classified meetings.

J. J. Barton Photo

PARTICIPANTS in the Institute's 75th Anniversary Meeting were: (*left to right*) R. S. Hewett, chairman of the Philadelphia Section; AIEE President J. H. Foote; Past President L. F. Hickernell; and R. L. Halberstadt, chairman of the 75th Anniversary Committee.

FEATURED speakers at the AIEE Diamond Anniversary celebration were: Brigadier General David Sarnoff (*left*) and Vice-Admiral J. T. Hayward (*right*), Deputy Chief of Naval Operations, U.S. Navy.

J. J. Barton Photo

The Institute and Philadelphia: 1884

An historical resume of conditions in the United States at the time of the first AIEE meetings as well as an account of the opening of the International Electrical Exhibition, and the reaction to the exhibits of Sir William Preece, AIEE's first Honorary Member, were described by Past President Hickernell. He also commented on the particular significance of two of the papers presented at the historic first meeting. One paper, by Rowland R. Hazzard, AIEE's first treasurer, demonstrated considerable foresight by presenting a colored cross-section drawing of a proposed layout for Broadway, New York City, with a suggested allotment of space for two local and two express subway tracks, pipes, conduits, and all facilities then foreseen. The other paper was by Edwin J. Houston, a Philadelphian who was then head of the natural sciences department of Central High School. Entitled "Notes on Phenomena of Incandescent Lamps," it dealt with an observation noted by Edison—known as the Edison effect—which actually was thermionic emission upon which modern electronics is based. Although Edison had obtained the first patent in the field of electronics in 1884, it was 20 years later that further development in this field took place.

In conclusion, Past President Hickernell pointed out that the use of electricity in the exploration of space is just beginning and that electrical engineering and science will continue to gain in importance because without it there could be no

J. J. Barton Photo

THE DAVID SARNOFF MEDAL was presented to General Sarnoff (*standing, right*) by AIEE President J. H. Foote (*standing, left*) on the occasion of the 75th Anniversary Celebration of AIEE's first technical meeting.

space age. The complete address appears on pages 1152-57 of this issue.

Presentation of David Sarnoff Medal

The establishment of the David Sarnoff Gold Medal Award and the achievements of General Sarnoff were related by President Foote, who outlined David Sarnoff's rise to positions of board chairman and director of Radio Corporation of America Communications, Inc., and the National Broadcasting Company, from the time Mr. Sarnoff entered the radio communications field in 1906 as a messenger boy, and became a wireless operator for the Marconi Company at Siasconset, Mass., two years later. The many honors he received include the Legion of Merit and the Medal for Merit, as well as the Army's highest civilian honor, the Decoration for Exceptional Civilian Service. He was commended for his great vision and foresight in conceiving the idea of the "Radio Music Box" in 1916, as well as forming the first radio broadcasting network in 1926, the introduction of television as a service to the American people in 1939, and setting the goal for compatible color television which was approved by the Federal Communications Commission December 17, 1953.

By authority of the Board of Directors, President Foote presented General Sarnoff with the first David Sarnoff Medal that contained the following citation:

> "This special inaugural award of the David Sarnoff Medal is made to David Sarnoff October 7th, 1959 on the 75th anniversary of the first technical meeting of AIEE in recognition of his inspiring and courageous leadership in the advancement of the art and science of electronics."

Address by General David Sarnoff

In response, General Sarnoff stated that no one today could chart the course upon which humanity will travel for the next 50 or 75 years. As an illustration, no one at the turn of the century would have mentioned Lenin, Stalin, Khrushchev, Hitler, Freud, or Michelson or Einstein, yet those few names have altered the course of history. He stated that it is not the known things that are always the most important, but the unknown, and those things which the human mind cannot envision and encompass that ultimately come to affect the whole universe. Speaking as a communications man, General Sarnoff asserted that all the developments since Morse invented the telegraph, Marconi the wireless, and others built on top of that, would prove of much less importance than the developments to come in the next 50 years, or in the next 20 years, and possibly within the next 10 years.

Satellite communications within the coming decade were believed to be a certainty; and, with one or two satellites 22,000 miles or so above the earth, by means of microwave radio relays, it might be possible to communicate with every part of the world, not only by telegraph, but telephone, television--even in color, with data-processing information and facsimile. It was also stated that the day might be seen when communication from person to person might be possible regardless of the shortage of frequencies, when each person will be able to carry a little pocket device able to transmit and receive and reach another person directly through microwave radio relays.

In conclusion, General Sarnoff drew attention to the need for an understanding of the humanities in the field of science and technology, since, by virtue of modern developments, there exists a much greater responsibility individually and selectively than heretofore. Science in its rapid strides has produced two devices which are capable of destroying mankind as well as providing beneficial services and goods. Hence, the engineer and the scientist must expand their own mental horizons. He considered the problem of the educator at the present time to be just as important as the problem of the inventor, if not more so, for education must be concerned, not only with knowledge, but must also train the individual to think. Wisdom must accompany knowledge, for knowledge without wisdom can create a great menace, and the new tools and instrumentalities that have been invented must be used wisely if a catastrophe to mankind is to be avoided.

Vice-Admiral Hayward's Address

"Advance in Electrical Engineering Is Synonomous with 'The Navy Research and Development Program'" was the subject of Vice-Admiral Hayward's address.

In his survey, he mentioned the fact that at about the time the Institute was founded in 1884 and just prior to the International Electrical Exhibition, the *U.S.S. Trenton* was being fitted with electric lighting. Three years later, *United Services*, the Army and Navy Journal of the day, noted that 150 ships had been fitted with electric lighting, and in 1890, electric welding was used aboard ships. One year later, electric power on shipboard was in great demand for training and elevating heavy guns and for a variety of other applications. The telephone was already being considered for use aboard ship, and toward the turn of the century, the Navy was giving attention to the prospects of wireless telegraphy.

Those times produced technical leaders in the Navy of the calibre of Admiral S. M. Robinson, just as today, the upsurge of scientific achievement has produced officers such as Admiral H. G. Rickover. Admiral Robinson and others were instrumental in the introduction of electric drive to naval ships. The first application of turboelectric drive was to the collier *Jupiter* which, as a harbinger of things to come, was converted to the world's first aircraft carrier, the *USS Langley*.

During World War I, electrical technology produced very-low-frequency radio useful to communicate with submarines, and in the 1920's, electrical technology brought forth a workable high-frequency radio. The aircraft and the submarine were the essential elements of military fighting power in World War II, and we were nearly defeated by both, but it took both to help win the war. The Admiral congratulated the engineers on the splendid job done during the first threescore years of their existence as a technical entity and warned that engineers could not rest on their laurels.

It was pointed out that the genius of the human mind has made available weapons that could conceivably incinerate the earth and exterminate all life. Again, the aircraft will soon be displaced by the ballistic missile and these together with the submarine comprise the principal

AIEE Future Meetings

AIEE-IRE-ACM Eastern Joint Computer Conference*
Statler Hilton Hotel
Boston, Mass.
November 30-December 3, 1959

AIEE-IRE Midwest Symposium on Circuit Theory*
Marquette University
Milwaukee, Wis.
December 1-2, 1959

AIEE-NEMA Second National Conference on Application of Electrical Insulation*
Shoreham Hotel
Washington, D. C.
December 8-10, 1959

AIEE-IRE-ASQC Symposium on Reliability and Quality Control*
Hotel Statler
Washington, D. C.
January 11-13, 1960

Winter General Meeting*
Hotel Statler
New York, N. Y.
January 31-February 5, 1960

AIEE-IRE-U of P Solid State Circuits Conference*
University of Pennsylvania
Philadelphia, Pa.
February 10-12, 1960.

Engineering Aspects of Magnetohydrodynamics Conference
University of Pennsylvania
Philadelphia, Pa.
February 18-19, 1960
(Final date for †TP—closed, ‡CP Syn.—Dec. 4, CPMs—Dec. 15)

AIEE-IRE-AEC-NBS Scintillation Counter Conference
Shoreham Hotel
Washington, D. C.
February 25-26, 1960
(Final date for †TP—closed, ‡CP Syn.—Dec. 11, CPMs—Dec. 22)

EJC Nuclear Congress
New York Coliseum
New York, N. Y.
April 3-8, 1960

Southwest District Meeting
Shamrock-Hilton Hotel
Houston, Texas
April 4-6, 1960
(Final date for †TP—Jan. 4, DPMs—Jan. 29)

Electrical Engineering in Space Technology Conference
Hotel Baker,
Dallas, Texas
April 11-13, 1960
(Final date for †TP—Jan. 12, ‡CP Syn.—Jan. 26, CPMs—Feb. 5)

East Central District Meeting
Daniel Boone Hotel
Charleston, W. Va.
April 12-14, 1960
(Final date for †TP—Jan. 13, DPMs—Feb. 5)

AIEE-ASME Railroad Conference
Penn-Sheraton Hotel
Pittsburgh, Pa.
April 13-14, 1960
(Final date for †TP—Jan. 14, ‡CP Syn.—Feb. 8, CPMs—Jan. 29)

AIEE-ASME-IRE Automatic Techniques Conference
Sheraton-Cleveland Hotel
Cleveland, Ohio
April 18-20, 1960
(Final date for †TP—Jan. 19, ‡CP Syn.—Feb. 2, CPMs—Feb. 12)

Paper and Pulp Conference
University of Florida
Tallahassee, Fla.
April 21-22, 1960
(Final date for †TP—Jan. 22, ‡CP Syn.—Feb. 5, CPMs—Feb. 16)

Rubber and Plastics Conference
Sheraton-Mayflower Hotel
Akron, Ohio
April 25-26, 1960
(Final date for †TP—Jan. 26, ‡CP Syn.—Feb. 10, CPMs—Feb. 19)

Great Lakes District Meeting
Pfister Hotel
Milwaukee, Wis.
April 27-29, 1960
(Final date for †TP—Jan. 28, DPMs —Feb. 22)

North Eastern District Meeting
Sheraton Biltmore Hotel
Providence, R. I.
May 2-4, 1960
(Final date for †TP—Feb. 2, DPMs) —Feb. 26)

AIEE-IRE-ACM Western Joint Computer Conference
Jack Tar Hotel
San Francisco, Calif.
May 3-5, 1960
(Final date for †TP—Feb. 3, ‡CP Syn.—Feb. 19, CPMs—Feb. 29)

AIEE-IRE-EIA-WCEMA Electronic Components Conference
Washington, D. C.
May 10-12, 1960
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 26, CPMs—March 7)

Farm Electrification Conference
Sheraton-Fontenell Hotel
Omaha, Nebr.
May 10-12, 1960
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 26, CPMs—March 7)

Annual Cement Industry Technical Conference
Pfister Hotel
Milwaukee, Wis.
May 17-19, 1960
(Final date for †TP—Feb. 17, ‡CP Syn.—March 4, CPMs—March 14)

AIEE-ISA-ARS-IAS National Telemetering Conference
Marimar Hotel
Santa Monica, Calif.
May 23-26, 1960
(Final date for †TP—Feb. 23, ‡CP Syn.—March 9, CPMs—March 18)

Summer General Meeting
Chalfont-Haddon Hall
Atlantic City, N. J.
June 19-24, 1960
(Final date for †TP—March 21, ‡CP Syn.—March 31, CPMs—April 15)

Pacific General Meeting
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs—June 3)

Aero-Space Transportation Conference
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960
(Final date for †TP—May 10, ‡CP Syn.—May 20, CPMs—June 3)

AIEE-ASME Engineering Management Conference
Morrison Hotel
Chicago, Ill.
September 14-16, 1960
(Final date for †TP—June 16, ‡CP Syn.—July 1, CPMs—July 11)

AIEE-ASME National Power Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
September 21-23, 1960
(Final date for †TP—June 23, ‡CP Syn.—July 8, CPMs—July 18)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 9-14, 1960
(Final date for †TP—June 10, ‡CP Syn.—July 21, CPMs—Aug. 5)

*Final date for submitting papers—closed

†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Author's Guide*.
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N. Y.

military threats. Never before has the engineering profession been called upon to perform in the face of technical problems as baffling as defenses against the nuclear submarine and the ballistic missile. The bulk of the problems associated with today's antisubmarine warfare and antiballistic missile warfare are electrical or electronic engineering problems.

In conclusion, Admiral Hayward stated that the Navy man's problems of the future will be greater than ever before, and he made a strong appeal to engineers to design equipment so that the frail human man would be able to cope with the problems of defense against ballistic missiles, nuclear submarines, and thermonuclear warfare.

Detailed Arrangements Made for 1960 AIEE Winter General Meeting

THE AIEE Winter General Meeting will be held January 31-February 5, 1960. Because of the large number of technical sessions covering all six technical divisions of the Institute, meetings will take place in both the Statler-Hilton and the Sheraton-Atlantic Hotels, New York, N. Y. As usual, the Statler-Hilton will be headquarters for the meeting.

As this is being written, 121 sessions are being organized and 218 formal papers have been submitted for consideration of publication in the *Transactions*. It may be expected that approximately 600 Transactions and Conference papers will be presented.

Informal Tea

This social gathering before the formal program begins has been enjoyed by more and more persons each year. This year, the informal tea will be held Sunday afternoon, January 31, from 4 p.m. to 6 p.m. in the Ballroom of the Statler. There will be no charge.

From 2 p.m., the registration facilities will be open for those who wish to avoid the Monday morning rush.

Hotel Reservations

Blocks of rooms have been set aside at the Statler and Atlantic (formerly McAlpin) and nearby hotels for members and guests attending the meeting.

Requests for reservations should be sent to the following hotels at the daily rates indicated:

Hotel Statler-Hilton (meeting headquarters), 7th Ave., 32nd St. to 33rd St.

Single Room	$ 8.00 to $15.00
Double Room	11.00 to 20.00
Twin Bedroom	15.00 to 25.00

Hotel Sheraton-Atlantic (formerly McAlpin), Broadway and 34th St. (also used for meetings)

Single Room	$ 8.50 to $14.00
Double Room	12.00 to 17.00
Twin Bedroom	14.00 to 18.00

All rooms have private bath and the rates quoted are subject to a 5% New York City hotel room tax.

A request for reservations should be made to only one hotel and specific reference to the AIEE meeting should be made. If the request cannot be filled, the hotel will automatically refer it to the Hotel Accommodations Committee whose duty it is to obtain a similar reservation at another nearby hotel. The hotel will confirm each request directly to the persons attending the meeting. Because of crowded conditions in New York hotels, it is suggested that your reservations be made for arrival on Sunday to avoid delays in registration and the unavailability of rooms in the early morning of subsequent days.

Smoker

One of the social highlights of the Winter General Meeting will be the Smoker on Tuesday evening, February 2, in the grand ballroom of the Hotel Statler. Here will be found good food, good fellowship and top quality entertainment.

The seating capacity has been reduced from previous years to permit a greater amount of comfort and better average enjoyment by the guests. For this reason it is strongly recommended that requests for tickets be sent in at an early date. The price of the ticket will be $11.50 and requests should be addressed to "AIEE Smoker Committee" at 33 W. 39th St., New York 18, N. Y., and accompanied by checks made payable to "Special Account, Secretary, AIEE."

Dinner-Dance

The Dinner-Dance will be held Thursday evening, February 4, in the Hotel Statler. Dress will be formal. Write soon for reservations for tables for 10. The price this year is $13.50 per ticket and requests should be sent to "AIEE Dinner-Dance Committee" at 33 W. 39th St., New York 18, N. Y., accompanied by checks made payable to "Special Account, Secretary, AIEE."

Panel Discussion

Sponsored by the Electrical Techniques in Medicine and Biology Committee, a panel discussion will be held Thursday, February 4, beginning at 9 a.m., on the topic, "New Challenges to Electrical Engineers from Medical and Biological Problems." Well-known investigators in the fields of physiology, radiology, biology, and space medicine will be present.

Dr. A. R. Eckels, chairman of the electrical engineering department of the University of Vermont, will be the moderator. Space medicine will be discussed by Dr. Albert Hetherington, technical director, Life Sciences Directorate, Air Research and Development Command.

Inspection Trips

A program of inspection trips is presently being prepared which will include many of the more popular trips scheduled in prior years as well as others that have not been available previously. Included in the schedule are trips to: Bell Telephone Laboratories; Brookhaven National Laboratories; Consolidated Edison Company's Astoria Generating Station and Indian Point Generating Station; Fairchild Camera and Instrument; Holophane Light and Vision Institute; International Business Machines Corporation; New York Times; Okonite Cable Company; Public Service Electric & Gas Company's Bergen Generating Station; Radio City Music Hall; Rambusch Decorating Company; Underwriters' Laboratories; and United Nations General Assembly.

As in the past, advanced registration will be accepted for selected tours.

John Scott Award

A feature of the meeting will be the presentation of the 1959 John Scott Award to D. A. Lyon (AM '29) of Woodbridge, Conn., an American physicist. Dr. Lyon was honored for his invention of the method of producing the first practically useful optical coatings for the reduction of light reflection.

The award, which consists of a copper medal, a scroll bearing the citation, and a cash prize of $1,000, was established by John Scott, a chemist of Edinburgh, Scotland, who upon his death in 1816 bequeathed funds in trust to the City of Philadelphia to reward ingenious men and women who contribute useful inventions.

Dr. Lyon's invention—the method of producing optical coatings—placed on optical elements such as lenses, prisms, and the like, a very thin hard coating which greatly reduced light reflection from the surface. This reduction of reflection permitted more light to pass through the lens, making it much more useful. During World War II, the periscopes of American and other submarines had so many pieces of glass in the lens system that they could only be used in bright light. Dr. Lyon's innovation so greatly improved the periscope that it was useful on very dark days and even at night. Improvements in cameras, field glasses, and many other optical devices have also been made through use of these optical coatings which are used on almost all such devices today.

Ladies Entertainment

The Ladies Entertainment Committee has planned an interesting program for the week.

The Ladies Headquarters and Hospitality Room will be open throughout the week, and there will be a coffee hour each morning, Monday through Friday.

The Ladies Program follows: *Monday* afternoon, a Get-Acquainted Tea will be held by courtesy of the Phelps-Dodge Copper Products Corporation. On *Tuesday* morning, the ladies will visit the new Guggenheim Museum. In the evening, the cocktail and ladies dinner party will be given, followed by entertainment. For *Wednesday* morning, a visit to "The Dec-

orators Mart" is scheduled. Breakfast will be served at Altman's *Thursday* morning. This will be the 10th visit there, and something special is promised. There will be a Luncheon and Fashion Show at the Waldorf-Astoria. Suggested short tours will be held *Friday*.

Registration: Ladies register with their husbands and obtain badges before getting tickets at the Ladies Headquarters for the events of the Ladies Program.

Winter General Meeting Committee

Members of the 1960 Winter General Meeting Committee are: R. T. Weil, Jr., chairman; R. W. Gillette, vice-chairman; J. J. Anderson, secretary; J. R. Kerner, budget co-ordinator and AIEE vice-president for District 3; C. T. Hatcher, chairman, Technical Operations Department; C. F. Savage, public relations; W. G. Vieth, general session; M. Lennig, hotel accommodations; F. P. West, registration; H. G. Koch, inspection trips; T. W. Bartlett, monitors; D. Halloran, smoker; E. J. Doyle, dinner-dance; Mrs. D. M. Quick, ladies entertainment; and D. M. Quick, ex-officio member (past-chairman).

Wear Your ◆ AIEE Badge

Outstanding Young Engineers of 1959 Are Named by Eta Kappa Nu

DR. E. A. SACK, JR. (AM '54) of Pittsburgh, Pa., has been named the Outstanding Young Electrical Engineer of 1959 in the annual nationwide talent search conducted by Eta Kappa Nu, national electrical engineering honor society. Honorable Mention awards in the national competition have been made to W. O. Fleckenstein of Whippany, N. J.; K. H. Olsen of Bedford, Mass.; and J. W. Wentworth of Haddonfield, N. J.

The 1959 competition is the 24th in the series which began in 1936. Formal presentation of the awards will be made in February at a banquet to be held during the Winter General Meeting of AIEE in New York City.

At 29 years of age, the Outstanding Young Electrical Engineer of 1959 has an enviable record of accomplishment in the field of solid-state device research and development. Initially, Dr. Sack contributed to the understanding of dielectric amplifiers through his doctoral research in connection with ferroelectric materials and their use in resonant dielectric amplifiers. Most recently, he has been responsible for advances in electroluminescence and the application of this principle to practical solid-state display mechanisms. His efforts have made possible an electroluminescent alpha-numeric and digital indicator as well as high resolution microcircuit structures for flat panel mural television displays valuable for U.S. Navy command information centers. He supervised the design and installation of the first full scale installation of electroluminescent panels for room lighting in 1956.

He received his education, through the doctorate in electrical engineering, at Carnegie Institute of Technology, where he was awarded the bachelor's, master's and doctor's degrees in 1951, 1952, and 1954, respectively. He joined the Research Laboratories of Westinghouse Corporation in 1954 as a member of the Television Section of the electronics and nuclear physics department. At present he is manager, Dielectric Devices Section, responsible for the direction of research on special dielectric devices such as electroluminescent displays.

By no means has Dr. Sack limited his activities to technical matters. He was extremely active in church work in Mount Oliver, Pa., for 10 years. He actively supported a political candidate for commissioner in Penn Hills, Pa., in the 1959 primary elections, and he has been an active member of a volunteer fire company since 1956. He is a licensed radio amateur and a high fidelity enthusiast.

Honorable Mention

Mr. Fleckenstein, one of the Honorable Mention citation recipients, is 34 years of age. A native of Scranton, Pa., he was graduated from Lehigh University as the highest ranking senior in electrical engineering in 1949. He joined the Bell Telephone Laboratories, Inc., immediately upon graduation and participated in their Communication Development Training Program. Upon completion of the program, he began a telephone career which has been marked by creative accomplishment.

Mr. Fleckenstein's principal contributions have been made in the areas of electronic switching systems, high-speed magtronic core memory systems, and data-transmission and record communication systems. He has taught extensively in the Laboratories' Communication Development Training Program, and he has been extremely active in community youth programs.

Brilliant engineer transformed to successful business executive is an accurate description of Mr. Olsen, another Honorable Mention recipient. At age 33, he has already earned an enviable record as a specialist in the development of solid-state components and circuitry for digital computation equipment. In addition, he is the founder and president of a corporation that had annual sales in excess of $1 million within 2 years of its organization.

Mr. Olsen, a native of Bridgeport, Conn., received the B.S. and M.S. degrees in electrical engineering from the Massachusetts Institute of Technology (MIT) in 1950 and 1952, respectively. As a graduate student, he invented a magnetic matrix switch for use with coincident current magnetic memories. Following graduation, as a staff member of the Digital Computer Laboratory of MIT, he supervised the group responsible for the first digital computer to use the magnetic core random-access memory. Later, he was one of the first to build a high performance digital computer using transistors. In 1957, Mr. Olsen founded and became president of Digital Equipment Corporation, a concern that has had remarkable financial success in the creation and marketing of transistorized building blocks for the computer industry.

The field of electronics also contributed the third winner of an Honorable Mention citation in the 1959 competition. Mr. Wentworth, 33, is manager of television terminal engineering in the Industrial Electronic Products Division of the Radio Corporation of America (RCA). Born in Greenville, Maine, he was graduated from the University of Maine in 1949 with a bachelor's degree in electrical engineering. He joined RCA shortly after graduation and has been a major contributor to that organization's important advances in color television. More than 100 commercial products in this field have been influenced materially by his rare combination of engineering and administrative ability.

Mr. Wentworth has taught and lectured extensively on the subject of color television. His book, "Color Television Engineering," was published in 1955. His lecturing has also extended to lay preaching in the Methodist church of Haddonfield, N. J. He played a major role in the rebuilding program after his church was gutted by fire in 1956 and has been most active in church conferences, seminars, and study programs.

Eligibility Rules

The Eta Kappa Nu recognition of the Outstanding Young Electrical Engineer is intended to emphasize among electrical engineers that their service to mankind is manifested not only by achievements in purely technical pursuits but in a variety of ways. It holds that an education based upon the acquisition of technical knowledge and the development of logical methods of thinking should fit the engineer to achieve a substantial degree of success in many lines of endeavor. Eligible for the award is any man who on May 1 of each year has been graduated not more than 10 years from a regular course in electrical engineering taken at an American college or university and who is not more than 35 years of age. Selection is made on the basis of the candidate's record of achievement in his chosen work; in his service in behalf of his community, state, or nation, in his cultural or aesthetic development; and for his professional activities.

Eta Kappa Nu, the sponsor of the annual award, is the national electrical engineering honor society founded at the University of Illinois in 1904. The organization has more than 28,000 members, 71 college and 12 alumni chapters in the principal cities of the U. S.

Selection of this year's recognition winner and honorable mention recipients was

made by a Jury of Award headed by Ernst Weber (AM '31, F '34), president, Polytechnic Institute of Brooklyn, and president, Institute of Radio Engineers. Others on the Jury of Award were: J. B. Browder, president, Illuminating Engineering Society; Larry Dwon (AM '36, M '43), administrative assistant to executive vice-president, operation, American Gas and Electric Service Corporation, and past president, Eta Kappa Nu; L. C. Holmes (AM '31, F '51), director of research, Stromberg Carlson Company, and vice-president, AIEE; A. G. Kandoian, vice-president, International Telephone and Telegraph Corporation Laboratories, Inc.; Albrecht Naeter (AM '23, F '53), professor and head, Electrical Engineering School, Oklahoma State University, Stillwater, Okla., and president, Eta Kappa Nu; and C. V. Roseberry (AM '47, M '51), vice-president, Westinghouse Electric Corporation.

To assist the Jury of Award in their deliberations, each year the nominations for the Outstanding Young Electrical Engineer are given a preliminary processing and evaluation by the society's Award Organization Committee. This group arranges for collection of references and other supporting data of use to the Jury of Award in the final judging. Every effort is made to secure nominations on a nationwide basis, and this year the records of candidates representing all the geographical areas of major engineering activity in the country were examined by the committee.

W. B. Groth (AM '52, M '56) was chairman of the Award Organization Committee. The committee members for 1959 included: Robin Beach (AM '15, F '35), who heads Robin Beach Engineers Associated; Mr. Dwon; J. E. Farley; N. S. Hibshman (AM '27, F '41), secretary, AIEE; C. T. Koerner (AM '35, M '53), staff engineer, Pacific Telephone and Telegraph Company; E. S. Lee (AM '20, F '30), associated with General Electric Company before retirement and former AIEE president; J. M. Monstream; J. H. Mulligan, Jr. (AM '44, M '54), professor and chairman, electrical engineering department, New York University; and R. I. Wilkinson (AM '35), traffic studies engineer, Bell Telephone Laboratories, Inc.

1,900 Members and Guests Attend AIEE Fall General Meeting in Chicago, Ill.

FOR THE 5TH TIME, Chicago was host to AIEE's Fall General Meeting held at the Hotel Morrison, October 11-16, 1959. The meeting was concurrent with the National Electronics Conference at the Hotel Sherman, and provision was made for joint registration. Social activities, technical sessions, and committee meetings engaged all facilities of the Hotel Morrison. The combined attendance exceeded 1,900 members and guests at the meeting's close.

There were 56 technical sessions at which more than 200 papers were presented. Rotating machinery and nucleonics were given special attention. The nucleonics sessions included papers covering the "Evaluation Studies of Reactor Concepts," recently completed by leading consultant firms for the Atomic Energy Commission.

Social activities included a reception tea and hospitality hour on Sunday afternoon, October 11, and the "Fall Frolics," held on Wednesday, October 14, in the Terrace Casino of the Hotel Morrison.

Inspection trips were made to operational and dispatching facilities of the Commonwealth Edison Company; Hubbard Electrical Research Laboratory; Electro-Motive Division of General Motors at La Grange, Ill.; Panellit Products Plant at Skokie, Ill.; Chicago & North Western Railroad for a view of new equipment; Chicago Harbor Authority; Underwriters' Laboratory, Inc.; Automatic Electric Company; and Argonne National Laboratories.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grade, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

General Session

The chairman of the Chicago Section, F. A. Cox, presided at the general session held in the grand ballroom of the Hotel Morrison October 12. J. G. Duba, the mayor's administrative officer, City of Chicago, welcomed the delegates.

Former AIEE President L. F. Hickernell, serving in the role of AIEE historian, reviewed some of the events of national and international significance that formed a background for the first technical meeting of the Institute 75 years ago. The full text of Mr. Hickernell's address appears on pp. 1152-57. Mr. Cox noted, in a postscript to Mr. Hickernell's talk, that the first AIEE section meeting took place in Chicago in 1892. The Chicago Section has grown from 21 members in 1893 to more than 2,400 members today, he said.

AIEE President J. H. Foote made a brief speech of reminiscence in which he stressed the importance of heritage in guiding the young engineer just emerging into a career. Progress, he said, is based on past achievements and ideas; the young engineer, therefore, must study and retain a curiosity about history if he is to be properly oriented toward the future. As for the Institute, it must be able to assimilate the young engineer by catering to his special needs. Committees have been appointed to study this matter as well as the related one of collaboration with other societies on a more dynamic basis, the president noted.

Murray Joslin, vice-president in charge of engineering, operating, and construction, Commonwealth Edison Company, delivered the principal address on the growing conflict between engineers, scientists, and management. This conflict is being exacerbated, he said, by the increasing dependence of our society on the contributions of the engineer-scientist group. Another factor is the accelerating growth rate of this group in the over-all working force. Mr. Joslyn feels, however, the conflict can be mitigated on the part of the engineer-scientist group by a more mature view of the special qualities and talents needed for management and, on management's side, by more self-appraisal and greater attentiveness to the needs of engineering and scientific personnel for recognition of achievement.

Institute Honors Three Engineers

Dr. S. R. Warren, Jr., aided by President Foote, presented Institute medals for professional achievement to three leading engineers at the general session. Two of the medals, the Morris E. Leeds Award, which was presented to Dr. H. B. Brooks of Washington, D. C., and the William H. Habirshaw Award, which went to W. A. Del Mar, Yonkers, N. Y., were presented for the first time. The third award, the AIEE Medal in Electrical Engineering Education, was presented to Dr. G. S. Brown, dean of engineering, Massachusetts Institute of Technology (MIT), Cambridge, Mass. Each award consisted of a medal, a certificate, and $500.

The Leeds Award was established in 1958 by the Leeds and Northrup Foundation to honor an individual or group who has benefited the arts and sciences by making an outstanding contribution to the field of electrical measurement. Dr. Brooks, who is 90 years old, is the retired chief of the Electrical Section of the U. S. Bureau of Standards (NBS). He was a member of the NBS since his graduation from Ohio State University in 1903 until his retirement in 1946. His best known inventions are: deflection potentiometer, a variable self and mutual inductor (the so-called inductometer), and the standard cell comparator. Since retirement, he has published two papers, "Electrical Indicating Instruments Used in Early Edison Central Stations," and "Inductive Efficiency of Reactive Coils."

The Habirshaw Award was established in 1958 by the Phelps-Dodge Foundations to honor individuals or groups who have made outstanding contributions to the field of transmission and distribution. Mr. Del Mar is a consulting engineer for the Phelps-Dodge Copper Products Corporation, from which he retired in 1952 as chief engineer after 35 years of service. Born in San Francisco, Calif., in 1880, he was graduated from City and Guilds College, now an affiliate of the Imperial College of Science and Technology and the University of London. His early experience was with transmission and distribution for electric railroads. He was technical assistant in the electric traction department of the New York Central Railroad during the electrification of its New

York area. He also was assistant electrical engineer for the Interborough Rapid Transit Company, New York, N. Y., and was charged with co-ordinating into one system the three separate transmission and distribution systems of the elevated, surface, and subway systems.

The Medal in Electrical Engineering Education was established by the AIEE Members-for-Life Fund Committee to be awarded annually to a teacher of electrical engineering, "based on his teaching experience, ability to inspire students to higher achievements and capability, contributions to the teaching of electrical engineering in textbooks and in writings on engineering education, active participation in the work of professional and educational societies, and contributions to teaching and the profession through research, engineering achievement, and technical papers."

Dr. Brown, recipient of the medal, was born in Australia in 1907. He received mechanical and electrical engineering degrees from the Melbourne Technical School, and a bachelor of science, a master of science and a doctorate, all in electrical engineering from MIT. He was named to the teaching staff in 1931, became a professor in 1946, head of the department of electrical engineering in 1952, and dean of engineering in 1959. In 1941, Dr. Brown established the MIT Servomechanisms Laboratory and was its director until 1952. In the past few years, he has become widely known for pioneer work in evolving a new synthesis of science and technology for training future electrical engineers.

PICS Chicago

AIEE MEDALS for professional achievement were presented by S. R. Warren, Jr. (*left*), vice-president of the University of Pennsylvania and chairman of the Recognition Awards Committee, to the following: G. S. Brown (*second from left*), dean of engineering, Massachusetts Institute of Technology, who received the medal for outstanding service in electrical engineering education; W. A. Del Mar (*third from left*), consulting engineer, Phelps-Dodge Copper Products Corporation, who received the William M. Habirshaw Award; and F. B. Silsbee (*right*), who accepted the Morris E. Leeds Award in behalf of H. B. Brooks, retired chief of the Electrical Instruments Section of the National Bureau of Standards.

Eta Kappa Nu Luncheon

At the Eta Kappa Nu luncheon, which was held Thursday, October 15, George Austin, chairman of the Chicago alumni chapter, presided. An address, entitled "The Genius of the Distinguished," was presented by President Foote. He pointed out that a distinguished product is judged by four principal standards: materials, design, workmanship, and performance. He then went on to show how these criteria apply to the make-up of a distinguished engineer. In the materials category would go such characteristics as personality, mentality, aptitude, interest, and potentialities. For design, the quality of the curriculum and teaching methods would be applicable. Workmanship implies the skill and competence he brings to the job. Performance represents the satisfaction of his work to employers, to himself, and to society.

Technical Sessions

High Energy Plasmas and Particles. This session, sponsored by the Nucleonics Committee, W. F. Gauster, chairman, heard a discussion of "Electric Space Propulsion" by J. C. Evvard, Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio. The electric rocket refers to a rocket system requiring electric energy from a possible nuclear source to accelerate the exhaust jet. Electric rockets can, in general, give exhaust velocities greater than are achievable by chemical means. The author predicted that electric space propulsion is perhaps 5 years away and will likely be first utilized for orbital guidance and vehicle orientation control. The electric power level will be low—perhaps less than 100 kw. Electric propulsion is also of considerable interest for lifting large payload fractions from low- to high-altitude orbits. Manned space journeys, Mr. Evvard said, must wait the development of larger booster systems. At least 10 to 20 years will be required before manned electric spacecraft in the several megawatt ranges are feasible.

R. G. Mills, Princeton University, spoke on "The Quest for Thermonuclear Power." There is vigorous competition amongst nations to achieve commercial power from fusion processes, Mr. Mills noted. The reasons are: (1) World power bankruptcy—the use of power is growing at an exponential rate so that some experts see power exhaustion in 200 years if new sources cannot be found and exploited; and (2) National prestige—each country would like to say it was first. The basic physical problem is to achieve a temperature of at least 100 million degrees to overcome electrostatic forces of repulsion keeping hydrogen nuclei from fusing. Problems exist as to how to heat gas, and how to confine it long enough to the job. Electrical and magnetic forces offer the most promise, he said. As to who will win the race, that is an open question, but three questions should be asked of any claims to achievement: (1) What is the temperature? (2) How long can it be maintained? (3) What is the neutron production?

H. S. Snyder, Brookhaven National Laboratory, presented a companion paper on the "Modern Magnetic Accelerators."

Communication Theory. R. L. Shuey, General Electric Company, presided at a session on communication theory. Philip Fire, Sylvania Electric Products, Inc., described a class of parity-check error-correcting codes, specifically designed for correcting nonindependent multiple errors in data transmission and processing systems.

H. F. Harmuth of Stromberg-Carlson Company discussed the transmission of information by orthogonal time functions. Items considered included transmission through a noise-free channel, influence of noise, and design requirements for a communication system using orthogonal functions.

In his paper "Network Response to Transient FM Inputs," T. T. N. Bucher, Radio Corporation of America, presented an approximation technique for calculating response of a linear passive network to pulse-like and step-like frequency modulating functions.

G. I. Cohn, Illinois Institute of Technology, discussed the nonlinear effects of ionized media on radio communication systems performance.

Transformers. A Tuesday afternoon session sponsored by the AIEE Transformers Committee opened with a paper on internal faults of gas-insulated transformers by G. Camilli, L. G. Littlejohn, and W. A. Wooldridge, all of the General Electric Company. The paper discusses the behavior of these transformers under fault conditions and reports results of tests which have been made on representative apparatus.

Tests have been conducted to determine the effects of internal explosions on oil-filled transformers, as outlined in a paper

PICS Chicago

CONDUCTING the general session of the Fall General Meeting were: *(left to right)* F. A. Cox, chairman of the general session; AIEE President J. H. Foote; Murray Joslin, vice-president in charge of engineering, operating, and construction, Commonwealth Edison Company, who delivered the main address; and E. H. Finch, general chairman of the Fall General Meeting.

by R. J. Ringlee and N. W. Roberts, General Electric. Results obtained from the tests and from analytical work described demonstrate that the deflection characteristics of the tank and the location of the fault have greater influence on the pressure of the tank wall, in most cases, than the presence or size of gas space.

A new phase-isolated load-tap-changing transformer is unique in that it provides 3-phase transformation with independent single-phase regulation controlled by means of separate sensing circuits for each phase. This design, which provides operational advantages over formerly available 3-phase equipment and economic advantages over the combination of equipment required to provide an equivalent installation, was described in a paper by F. P. Kaspar of Oklahoma Gas & Electric Company and J. S. Holtzinger and G. A. Wilson, both of McGraw Edison Company.

Radio Communication Systems and Television and Aural Broadcasting. "Microwave Radio Relay System with Demodulating Repeaters for Television and Multiplexed Telephone," a paper by J. J. Clarke, Radio Corporation of America, revealed the growing demand for interconnection of small groups of stations as well as widely separated facilities of single stations. Community antenna systems and other closed-circuit installations are adding to such demands. Since 1955, when this system was first introduced as an efficient and economical means of transmitting and distributing televison signals for intercity and television applications, almost 600 links covering 10,000 circuit miles have been established. The system, known as *TVM-1*, superseded an earlier type designed just after World War II which was not intended for multihop service. This capability has been achieved in the *TVM-1* system by the inclusion of high-quality color transmission as a necessary characteristic. For systems up to 200 or even 300 miles, the *TVM-1* system has proved very satisfactory, the author said. The system has many other special applications, including telemetry, data transmission, and multichannel telephony.

C. F. Otis, Philco Corporation, discussed the design of a transistorized portable television receiver recently built by Philco. Unique features include a projection viewing system which considerably increased the portability efficiency factor K (picture size in square inches divided by pounds). By placing the object to be viewed between a spherical mirror and its focal point, a virtual magnified image is formed which appears to come from behind the mirror. The image obtained is not formed by the real intersection of the light rays but by their apparent or virtual intersection. Thus, the name, "virtual image."

Rotating Machinery. Cracks found in the hub of the rotor spider of a 15,000-kva water wheel generator in 1953 caused concern. At that time, stresses in the spider were relieved by drilling all 76 dovetails in the laminated rim with 1-inch holes so that the dovetail would partially collapse in case of overspeed, allowing the rim to float. Further considerations resulted in a decision to replace the spider. In their paper, "An Unusual Method for Replacing a Rotor Spider in a Water Wheel Generator," W. R. Small, Jr., Pennsylvania Power and Light Company, and P. M. Bell, Westinghouse Electric Corporation, discuss the method used to install the new spider. This method pressed out the old spider leaving the laminated rim and field poles intact, then expanded the rim with heat and pulled the new spider into place.

E. A. Boulter discussed the application of a modified version of AIEE no. 511 to functional evaluation of high-voltage asphalt mica flake generator insulation. His paper was entitled "Functional Evaluation of High-Voltage Turbine-Generator Insulation Using a Generette Core Model."

G. Hausen, P. P. Biringer, and G. R. Slemon, all of the University of Toronto, described a drive in which a wound rotor induction motor is supplied through a static-magnetic power modulator. The drive provides accurate, continuously variable control of speed at any setting up to synchronous speed in either direction of rotation. Other features of the drive are its low-speed regulation, its provision for acceleration and braking at controlled torque, with nearly linear transient response, low cost, and high reliability.

Transmission and Distribution. In order to survive and prosper in a competitive market, electric utilities, in common with all industry, conduct a persistent search for greater efficiency. K. W. Klein, Cleveland Electric Illuminating Company, in his paper, "Another Look at Distribution Transformer Loss Ratios," attempts to show how a change in transformer design may profit the utility industry by lowering the annual operating costs. If some typical averages hold for the next few years, the utilities may expect the number of distribution transformers to double within 8 to 10 years. This year, the electric utilities will spend an estimated $250 million on distribution transformers. With these dollars at stake, even a small per cent decrease in over-all annual cost means a significant savings.

E. G. Hammer and G. A. Rynders, Line Materials Industry, discussed "A New Concept in Capacitor Design." Tremendous increases in the use of electric power have produced high load demands and the need for electric distribution and transmission equipments of ratings higher than any previously available. The high load demands, it was said, have also brought about a corresponding need for additional capacitive kilovar on distribution and transmission systems. In the present state of the art and with proper safety factors applied, both the operating stresses and temperatures imposed on the dielectric have reached their apparent maximums. An entirely new concept in capacitor design to overcome these limitations has evolved. This new concept provides a means for removing the undesirable heat from the dielectric material and transferring it to the heat-dissipating tank surfaces.

L. H. Herenden, Jackson and Moreland, Inc., read a paper on "Distribution System Conversion to 4,160 volts."

Telegraph Systems. F. W. Smith, Western Union Telegraph Company, presided at a session sponsored by the AIEE Telegraph Systems Committee. M. L. Stephens, Lenkurt Electric Company, Inc., described the operation of the recently developed *23A* frequency-shift carrier telegraph system. Through use of transistors, an improved relay, and modular filters, the system is extremely flexible in its application, meets rigid performance specifications, and is compatible with existing telegraph plant facilities. A companion paper by T. B. Collins, Jr., of Automatic

Electric Sales Corporation and J. E. Pitts of Lenkurt covers the applications of this system.

The *84A1*, a small automatic teletypewriter message-switching system, is described in a paper by E. R. Shimmin, Pacific Telephone & Telegraph Company, and R. A. Vanderlippe and A. L. Whitman, Bell Telephone Laboratories, Inc. The unit was designed for businesses requiring more automatic communications than can be given by one or more separate selective calling lines. It provides for the automatic interchange of teletypewriter traffic between any number of half-duplex lines up to nine.

The eddy-current brake speed control system, designed to maintain a fixed phase relationship between transmission and recording devices for a facsimile circuit, was described by H. F. Burroughs, Western Union Telegraph Company. The control circuit, regulated power supply, and frequency standard, all transistorized, can be conveniently packaged in a volume of approximately $\frac{1}{8}$ cubic foot.

Organization of Computer Activities for Electric Utility Engineering. H. E. Cantrell, General Electric Company, provided a capsule view of the major factors involved in organizing to use computers. These include: the work to be done, approximate number of people involved, the question of whether a "computer organization" is needed, and the qualifications of the people doing the work. The paper was entitled "Organizing to Use Computers."

Some of the philosophy needed in the use of digital and other computers in the solution of electric utility problems was described by R. B. Shipley, Tennessee Valley Authority, in his paper "Computer Problem Analysis."

L. W. Coombe discussed the "Practicability of Computer Usage for Utility Engineering," a paper dealing with the present organizational arrangement and thinking regarding procedures for the use of digital computers for the solution of electric utility engineering problems at the Detroit Edison Company.

R. J. Brown, Bonneville Power Administration, presented a paper on "Some Experiences in System Engineering Computing."

Mining. Mining of submarine coal seams at distances up to 6 miles and depths of 2,850 feet present a particularly challenging problem to those who are responsible for these mines. J. J. Laffin, Dominion Steel and Coal Corporation, Ltd., in his paper "Mining with A-C Power in Dosco Mines," shows how these problems are being met and overcome through competent direction, engineering initiative, and skilled operation. The part that electricity plays in Dosco mining operations is demonstrated by the fact that 30 kwhr are consumed for every ton of coal produced.

A paper reviewing open-pit mine-power distribution practices was presented by R. B. Bennett and M. A. Neslin, General Electric Company.

F. R. Hugus, Joy Manufacturing Company spoke on the remote control of underground mining machinery.

Semiconductor Switching Devices and Applications. The paper making industry operates on a continuous basis 24 hours a day and usually 7 days a week. Unscheduled downtime for maintenance and repairs represents between $300 and $1,500 per hour in lost production depending on machine size and type of paper being produced. Under these conditions, equipment reliability of both the paper machine itself and the machine drive is of primary importance. For this reason, the silicon controlled rectifier is becoming an important component in electric drive systems for the paper industry. J. D. Grady, Oxford Paper Company, and R. I. Goodwin, General Electric Company, describe this device in their paper, "Application of Controlled Semiconductors in the Paper Industry." This static device, they point out, is now operating as a power amplifier in a number of paper machine drive systems replacing and providing the same functions as amplidynes, thyratrons, and magnetic amplifiers. These applications represent some of the very first industrial uses of this revolutionary new device which was only made available about 18 months ago. One of these installations has been operating approximately a year with no maintenance or replacement required for the controlled rectifier. N. F. Bechtold, U. S. Army Signal Research and Development Laboratory, presented a paper on "Performance of Semiconductor Rectifiers in a Pulse Radiation Environment."

E. Petrocelli, Westinghouse, spoke on a "Transistor A-C Switch."

Wire Communication. At a Thursday morning session, J. B. Eppes, Jr., Rural Electrification Administration, presided. The circuitry and performance of a commercially available transistorized multifrequency ringing generator were covered in a paper by J. F. Kostelich and B. W. Howald, both of Lorain Products Corporation. Initial and operating costs of this equipment are generally less than those of magnetic frequency changers and motor-generator sets.

F. H. Gardner, Stromberg-Carlson, described an all-transistorized trunk carrier system for increasing telephone communication facilities. Features include low power requirements (3 watts per channel per terminal), economy of installation, and plug-in modules to allow quick and easy service.

A transistorized repeater for a rural subscriber carrier system was described in a paper by W. S. Woods, Kellogg Switchboard & Supply Company, and A. R. Denz, International Telephone and Telegraph Corporation Laboratories. Emphasis was on the system parameters that were established as design goals for the repeater and the manner and extent to which these goals were achieved.

Excitation Systems. M. Temoshok, General Electric Company, presided at a Thursday afternoon session sponsored by the AIEE Power Generation Committee. A brushless excitation system, in which the collector, collector brushes, commutator, and commutator brushes can be eliminated, was described in two papers by Westinghouse engineers. In this system, excitation current is furnished to the field of a synchronous generator through a rotating rectifier from an a-c exciter, all of which are coupled to the generator shaft. The first paper, by E. C. Whitney, D. B. Hoover, and P. O. Bobo, discusses the reliability, ease of maintenance, and design considerations. In the second paper, by R. W. Ferguson, R. Herbst, and R. W. Miller, the analytical formulation computer simulation techniques, and performance evaluation of the proposed system are covered.

Some recent improvements in record-

AN INSPECTION TRIP to the Hubbard & Company Electrical Research Laboratory was made during the Fall General Meeting. AIEE members are shown here viewing the outdoor substation. The laboratory is located in McCook, a southwest Chicago suburb about 13 miles from the Loop. Opened in 1958, the laboratory was designed for developing and testing high-capacity and high-voltage equipment for power systems.

Beacon Photograph

ers and associated equipment used in the recording of turbine speed, eccentricity, expansion, and vibration were described in a paper by H. A. Harriman and D. M. Longenecker, both of the General Electric Company.

The inductor–alternator excitation system for turbine–generators, which has been successfully applied in eight installations since 1954, was outlined in a paper by W. L. Ringland and W. F. Eagan, both of Allis-Chalmers Manufacturing Company.

Relays and System Engineering. H. J. Sutton of Gulf States Utilities Company, chairman of the Survey of Relaying Practices Subcommittee of the AIEE Relays Committee, gave highlights of a report, prepared by the Subcommittee, covering practices and trends in protective relaying over the past 10 years. Two major trends were noted. First, in order to obtain lower capital investment per installed kva, circuit capacities and the unit size of equipment have been increased materially. Second, system components, investments, and operating costs have been minimized by careful design.

A. L. Toalston, Commonwealth Associates, Inc., outlined an approach for digital solution of short-circuit currents for networks which include mutual impedances. The method presented uses the short-circuit tensor and symmetrical components, with the same assumptions and basic data as are used for network analyzer studies.

A paper by W. E. Marter and J. L. Koepfinger, Duquesne Light Company, and C. W. King, Westinghouse, described a study conducted by Duquesne and Westinghouse concerning the application of a digital computer short-circuit program to 3-phase and phase-to-ground faults. It was found that automatic operation of the digital method is very attractive for several reasons, including speedy and reliable calculations, provision for a permanent record of the system studied, reduction of the likelihood of taking insufficient data, and a great degree of flexibility.

K. W. Eissman of General Electric concluded the session with the presentation of a paper on bushing potential devices with multiple ratings. These devices are advantageous to both manufacturer and user because they permit standardized production, inventory, and interchangeability.

PICS Chicago

JOINT REGISTRATION was provided for those attending the AIEE Fall General Meeting and the 15th annual National Electronics Conference (NEC), held concurrently October 12-14, 1959, in Chicago, Ill. Shown at the NEC, which met at Hotel Sherman, are: (*left to right*) J. H. Foote, AIEE president; V. H. Disney, NEC president; and R. B. Gear, AIEE vice-president, District 5. The NEC was sponsored jointly by the AIEE, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University, and University of Illinois.

Safety. A paper entitled "Fire Hazards and Safety Techniques in Wiring Homes, Offices, and Factories," highlighted this extremely important session. Robin Beach of Robin Beach Engineers Associates enumerated the "ill-advised" acts that cause most fire losses: (1) improper workmanship in the installation of electric circuits; (2) negligent maintenance of electric wiring, both at the consumers' premises and on the service lines of the power company; (3) lack of adequate understanding by those who install water, steam, oil, and gas lines, regarding the danger of placing grounded pipes across and in contact with electric armored cable, tubing, and conduit without the use of intervening insulation; (4) misinformed and wilful overfusing of circuits; and (5) failure, through inadequate or careless inspection of electric installations to detect and correct hazardous situations before they lead to trouble.

H. H. Watson, General Electric Company, presented a paper on "Higher Residential Voltages—Safety Considerations."

Business Conducted by Directors at Fall General Meeting in Chicago, Ill.

OF THE 35 active members of the Board of Directors, 33 met on Friday, October 16, 1959, the last day of the AIEE Fall General Meeting in Chicago, Ill. The major items of business concluded are reported in the brief summary that follows:

Finances

The Treasurer reported an operating cash balance including short-term investments of more than $325,000. A comparative statement of income and expenses for the first quarter of the fiscal year showed income exceeding that of last year for the same period by more than $60,000 while expenses are up $8,000. Dues income for the first quarter of the current year was up 4.6%. The balance sheet as of August 31 shows total assets of $2,356,793.

Bylaws

The Constitution and Bylaws Committee has undertaken to revise and codify the bylaws to supplement the new constitution approved by the membership in June 1959. The project is scheduled for completion at the June Board meeting. Meanwhile, the current bylaws underwent further amendment, effective October 16, 1959. In what follows, reference is given to the "old" bylaw now recorded in the "1959-60 Organization Manual" (O. M.). The amended current version, as approved by the Board of Directors, is given here:

Reinstatement of Membership

B22, B23 (O.M. pp. 151, 152)

"B22-23. Any applicant for readmission shall

first pay a re-entry fee, which shall be considered waived if the applicant had resigned in good standing. The re-entry fee, which shall be considered as satisfying all past dues indebtedness shown on the Institute's records, shall be equivalent to one-half of the current rate of dues for the grade of readmission. Upon satisfying the above, the applicant may be readmitted after review of his professional record by the Board of Examiners. The applicant shall then renew his membership privileges after payment of pro-rata dues for the year readmitted.

"Any reapplicant or member in good standing may at any time reinstate his original date of election or transfer by payment of dues at the currently prevailing rate of his grade of membership for the period of his lapsed membership.

"Retroactively paid years of membership in the Member grade shall not be considered as forming any part of the 10 consecutive years requirement for transfer to the grade of Fellow."

Publication Prices

B115, B121 (O.M. p. 164)

"B115. Each member is entitled to subscribe to one of the three bimonthly publications, *Communication and Electronics, Applications and Industry,* or *Power Apparatus and Systems,* or all three at the rate of $5.00 each per year. A second subscription to the same bimonthly publication or to all three may be obtained at the nonmember rate of $8.00 each per year."

"B121. Each member is entitled to subscribe to one or two parts of the Transactions Part 1—*Communication and Electronics;* Part 2—*Applications and Industry;* or Part 3—*Power Apparatus and Systems,* at the advance subscription rate of $4.00 each per year or to all three parts at the rate of $10.00 per year. The Secretary is authorized to receive from nonmembers advance subscriptions to one of the above mentioned parts of the Transactions at the rate of $8.00 per year, two parts at the rate of $15.00 per year, and three parts at the rate of $20.00 per year, plus extra foreign postage. Discounts from these prices may be allowed to college and public libraries of 25% and to publishers subscription agencies of 15%."

Membership Requirements

B127, B128 (O.M. p. 165)

"B127. Fellow grade of membership shall be conferred by action of the Board of Directors on those members whose outstanding work in electrical science or electrical engineering in any field is brought to the attention of the Board of Examiners by five or more Fellows or Members who shall submit data that in the opinion of the Board is sufficient to substantiate the importance of the accomplishment and warrant the issuance of the citation and conferring of the honor. Sponsors shall, when proposing a candidate for Fellow grade, give reference of five (5) Fellows. Transfer to Fellow may not be obtained by application.

"A Fellow shall at the time of transfer be at least 40 years of age. He shall have had at least 15 years of active experience, and shall have been in good standing in Member grade for at least 10 years immediately prior to the date of proposal for transfer to Fellow and shall qualify under C20.031 of the Constitution. As one measure of accomplishment under C20.031 'a' and 'b' he shall have been in responsible charge of such work for at least five years. A person who at the time of admission to the grade of Member held in good standing in a cognate electrical engineering society of national scope in any country, a grade of membership for which the qualifications indicate a standing equivalent to that required for the grade of Member herein, may have such years of prior membership in that equivalent grade, to a maximum of nine, considered as a part of the requisite ten years in Member grade."

"B128. At the time of admission or advancement to the grade of Member, the applicant shall be at least 30 years of age and actively engaged in the electrical field—temporary unemployment excepted. He shall have had at least ten years of active practice of the profession in one or a combination of several branches of the electrical field, indicative of growth in competency and achievement in that field and of a character satisfactory to the Board of Examiners and shall qualify under C20.041 of the Constitution. As one measure of accomplishment under C20.041 'a' and 'b' he shall have been in responsible charge for at least two years. Graduation in an engineering curriculum approved by the Board of Directors shall be credited as four years of this requisite ten years of practice.

"In addition, to qualify under C20.041 he shall have been in good standing in the grade of Associate Member for at least two consecutive years immediately prior to the date of application for the grade of Member, or as an alternative he shall have had at least three additional years in active practice during which time he shall have been in responsible charge of work as described in C20.041.

"A person who holds in good standing in a cognate engineering society of national scope in any country a grade of membership for which the qualifications indicate a standing equivalent to Member herein, shall have such membership considered as fulfilling requirements for Member grade in C20.041."

An Expanded Intersociety Relations Committee

"B(new). The Intersociety Relations Committee shall consist of nine members who shall be appointed by the President. The terms of appointment of one-third of the members shall expire at the close of each administrative year. (Experience with the major federation and intersociety groups should, to the extent feasible, be represented in the membership of the committee.) The chairman for each administrative year shall be designated by the President for that year. The committee shall organize, as necessary, to effectuate its assigned responsibilities.

"The committee shall report to the Board of Directors and shall be responsible for the following:

(a) Advising the Board on matters of policy with respect to current intersociety affairs.
(b) Representing the Institute in negotiations of new intersociety relations.
(c) Formulating methods for the application of Institute policy to intersociety problems.
(d) Promoting the implementation of Institute policies and programs in the field of intersociety relations.
(e) Carrying out any related activity assigned to the committee by the Board of Directors."

Intersociety Affairs

The Board authorized publication of a 150-page manual entitled "Organization of the Engineering Profession" to be used by the AIEE Sections as a basis for special meetings to study and discuss the "unity" problem and record member opinion on how best to achieve effective co-operation among engineers. The manual was compiled and written by the AIEE Intersociety Relations Committee which is also recruiting a 100-man Task Force to promote and assist the study, discussion, and opinion poll in the Sections.

Approval was voted for a revised charter of Engineers' Council for Professional Development.

Two new member societies were given AIEE approval for addition to the rolls of the Conference of Engineering Societies of Western Europe and the United States (EUSEC). On recommendation of Engineers Joint Council (EJC), the Board took the following action: (a) Agreed to enter into reciprocal arrangements with Constituent Societies of EJC for the exchange of member privileges of meeting attendance; (b) Voted to support the candidacy of Col. Sylvanus Thayer for the Hall of Fame; (c) Joined with EJC in nominating four members for the Board of Di-

Attention Members of AIEE

Original Dates of Election May Now Be Reinstated

DO YOU have a gap in your membership tenure—a period when, due to no fault of your own, you were forced to let your membership lapse for a few years before picking it up again? You may recall that if this lapse exceeded 3 years, or if the period was less than 3 years and you failed to exercise the option at re-election time, the Bylaws precluded you from ever restoring your original date of election. This has been changed so that now, perhaps when you can better afford it, regardless of the number of years lost you may restore your original election date and preserve the continuity of your AIEE membership. This may be accomplished by payment of dues at the current rate for your present membership grade for the period of your interrupted tenure.

If you are interested in the above, please complete the blank below and mail it to AIEE Headquarters.

American Institute of Electrical Engineers
33 W. 39th St.
New York 18, N. Y.

Gentlemen:

Please advise me of the cost of restoring my original date of election in AIEE.

NAME _____ **MEMBERSHIP NO.** _____
(PLEASE PRINT)

PRESENT MEMBERSHIP GRADE _____

ADDRESS _____

rectors of the National Science Foundation.

Institute Activities and Organization

The Board adopted in principle and authorized implementation of several important recommendations of the Special Task Force on Institute Activities and Organization which reported at this meeting after 20 months of intensive study. Some of the projects and plans to get under way as a result of this report are: (1) A New Activities Committee in the Technical Operations Department; (2) National Groups related to the technical and general committees carrying additional publications, meetings, and activities for all members interested in the subject; (3) A flexible publications policy to serve the new activities and groups; (4) a broadening of the voting membership requirements to include qualified professional scientists and engineers working in electrical science and engineering or close to it.

Honors and Elections

Nineteen Members were advanced to the grade of Fellow. Their biographies and pictures will appear in *Electrical Engineering*

Prof. Grimm, acting editor of the new student publication, *EE Digest*, and his associates, were complimented on the apparent success of the novel news-type paper issued in September and October in response to a Board authorization at its June meeting.

Board representatives to the Institute Nominating Committee were elected as follows: Representatives—Hendley Blackmon, W. H. Chase, W. R. Clark, R. B. Gear, E. W. Morris, J. C. Strasbourger. Alternates—W. R Brownlee, E. I. Green, L. M. Robertson, A. A. Johnson.

Future Meetings

The Board approved the following General Meetings to be added to the schedule: 1965 Summer General Meeting at Miami Beach; 1967 Summer and Pacific General Meeting at Portland, Oreg. Invitations were received for a 1964 Fall General Meeting in Cleveland, Ohio; a 1965 Fall General Meeting at Houston, Texas: and a 1969 Summer and Pacific General Meeting at Vancouver, B. C., Canada. District Meetings were announced as follows: District No. 1, Erie, Pa., May 14-16, 1962; District No. 2, Wilmington, Del., May 7-9, 1962; District No. 14, Pittsburgh, Pa., Spring of 1962; District No. 14, Cleveland, Ohio, May 1961, Cancelled.

Operational Problems Considered at Forum of Technical Committee Chairmen

THE 21ST FORUM of Technical Committee Chairmen, Vice-Chairmen, members of the Technical Operations Department (TOD), and TOD District Representatives was held on October 15, 1959, in Chicago, Ill., at the Fall General Meeting. The Forum was opened by C. T. Hatcher, chairman of TOD. Recommendations for committee appointments were discussed by President J. H. Foote, and a panel of three speakers presented talks on AIEE finances, implementation of the reduced budget to printed papers, and an appraisal of AIEE technical papers.

Recommendations for Committee Appointments

Attention was drawn by President Foote to the fact that TOD is the biggest operation in terms of the number of persons involved in relation to the entire membership of the Institute. He stated that 3,500 members are serving on the technical committees and, in just a few years, the Institute membership has grown from 35,000 to 50,000 members. The tremendous growth which the Institute has already experienced must be digested. Examples were cited of the thorough job of canvassing for committee appointments as done by several other organizations.

In conclusion, President Foote suggested that every chairman should begin now to rate the personnel of his committee first, second, and third, according to their qualifications, inasmuch as requests for recommendations for next year's committee appointments would be made in March.

AIEE Finances

The various items considered in formulating the budget for the fiscal year, May 1, 1959 to April 30, 1960, were reviewed by W. R. Clark, chairman of the Finance Committee. For the fiscal year ended April 30 1958, income exceeded expenditures by $85,313, but for the fiscal year ended April 30, 1959, expenditures exceeded income for a deficit of $65,934 Some staff positions were not filled during the year resulting in a saving of $25,000; if this had been expended, the deficit would have been $90,934. Last February, when it appeared that the deficit for the fiscal year ending April 30, 1959, would be larger than estimated, the Finance Committee reviewed the entire budget and urgent pleas were made to the various departments to keep their estimated expenses for the forthcoming year to a minimum. However, when the 1959-60 budget was prepared, the estimated expenses exceeded the estimated income for a deficit of $217,469. Realizing that the Institute could not continue to operate with deficit budgets, the Finance Committee called a special meeting to which the chairmen of all departments were invited, and all facets of income and expenditures were reviewed with a reduction in expenditures in each area to balance the budget. Expenditures in the revised budget estimate exceeded income by only $9,149. This budget was submitted to the Board which modified it so that the estimated expenditures exceed the estimated income by $51,949, representing an operating loss of about $1 per member.

Finance Committee Chairman W. R. Clark explained that this is not a healthy operating condition, but the expected deficit could be eliminated if everyone did their part. For example, a 10% increase in membership would just about balance the budget. If the advertising revenue for the fiscal year 1959–60 could be increased to that obtained in 1957–58, the expenditures would not exceed the income. In adjusting the budget, the Finance Committee recommended six ways of reducing expense and seven ways of increasing income which affected practically all phases of AIEE operations, not just the Publications Department or TOD. It was believed that limiting the number of Transactions papers to 500 would not seriously hamper TOD operations and that this restriction would help improve the quality of papers. Some members think quality improvement desirable.

Allocation of Budget for Papers

The allocations of quotas among the six technical divisions under the reduced budget for the publication of 500 Transactions papers and 250 Conference papers in the fiscal year 1959–60 were discussed by I. S. Coggeshall, vice-chairman of TOD. A tabulation which had been prepared just before the meeting showed that the forecast of the number of papers for the 1960 Winter General Meeting would exceed the allotment unless firm restrictions were applied. Division chairmen have been given these figures so that the problems and suggestions for solutions could be considered at their meetings The tabulation indicated that four of the divisions and all the general committees would be able to adjust to requirements within their total allotments by utilizing moderately the device of exchanging five Conference papers for one Transactions paper, or vice versa. General Applications and Science and Electronics Divisions had planned programs too large to be accommodated by manipulating their quotas and the TOD reserve was arbitrarily divided between them for relief; however, this was inadequate. It was stated that the degrading of Transactions papers to preprinted Conference papers solely with the intention of representing a large number of them as Transactions papers in the next fiscal year is futile and would merely result in publishing many papers for the record and for written discussion on a schedule perpetually one year late. Mr. Coggeshall said that there just does not seem to be any way to save printing and publication costs on a continually recurring annual basis without stopping the presses just before quotas are exceeded. This is what will have to be done.

In respect to the next fiscal year, Mr. Coggeshall did not see any relief in sight. He pointed out that the principal sources of income are membership dues, advertising in *Electrical Engineering*, and registration fees at meetings. Registration fees

(*Continued on page 1220*)

Two Out of Five* AIEE Members Know A New Building Is Needed

HOW ABOUT YOU?

OFFICE *(above, left)* **where the articles and departments of** *Electrical Engineering* **are edited and the pages of the magazine are made up and proof read.** *Above, right:* **From here are sent annually the hundreds of thousands of pieces of mail intended for AIEE Members. The shelves contain the great number of back publications which are constantly in demand by Institute Members.**

We are going ahead with the New United Engineering Center because we have confidence that you other 33,000 Members will do your share soon.

THE OFFICE of the Assistant Secretary for Technical Papers in which all technical and conference papers are processed, sent to reviewing committees, and released for preprinting.

21,000 Members out of 54,000 have contributed

(Continued from page 1218)

have been increased to a point of stress if not strain. Dues are hardly likely to be increased quickly enough to ameliorate the situation during 1960. Advertising has been adversely affected by cancellations accompanying the steel and copper strikes before recovering from the business recession of 1957–58.

In conclusion, the speaker raised several pertinent questions. This year the quotas were based on the division forecasts. Should this method be repeated or is another criterion better, such as the numbers of *Transactions* papers and Conference papers accepted this fiscal year? With the establishment of a New Activities Committee temporarily cutting across division lines to advance new frontiers such as Automation, Man Machine Relationships, etc., should not this new committee get equal call on papers allotments when the bulk is being distributed among the divisions? Do the present sizes of the three bimonthly publications represent the optimum balance among the divisions, and should they be continued or modified? Should TOD concern itself with this subject in allotting paper quotas?

Quality of Technical Papers

In a prepared paper, "An Appraisal of AIEE Technical Papers," the authors F. B. Arnold and C. F. Savage presented a method by which it was determined that the "quality" of AIEE technical papers had improved in the past decade. The method consisted of determining the characteristics of objectives of the Institute as defined by the constitution, and matching these with the characteristics of objectives of the authors' work yielding a profile match or "quality." A survey of more than 3,000 papers published in the AIEE *Transactions* from 1948 through 1958 was made. Statistical sampling methods were employed to obtain a sample size of 30 papers per year. Each paper selected for review and appraisal was examined and classified according to four major categories of engineering and research work and the yearly totals of papers in these categories were plotted. A smoothed-out version of the plot of the proportion of papers in categories 2 and 3 containing the greatest numbers of papers was interpreted as the significant rise in the quality of AIEE technical papers in the past decade. The methodology used in identifying the objectives of the Institute and the objectives of the paper and matching these as a measure of "quality" was believed to be useful.

In the discussion which ensued, W. R. Brownlee pointed out that the AIEE had preprints available in advance whereas some of the other societies did not have preprints and that this fact is related to quality. The suggestion was made to allocate a larger quota for papers to the Power Division which has based the *Transactions* on a bedrock foundation. In connection with the quality of papers, E. U. Lassen raised the question as to why there was a much greater number in category 2 and belief was expressed that categories 2 and 3 more nearly met AIEE objectives. President Foote drew attention to the value of permanency of technical papers and Hendley Blackmon expressed interest in any method which indicated that the quality of technical papers had improved. With regard to quotas for technical papers, past performance was believed to be a better method of forecasting; A. P. Fugill suggested taking history over a 3-year period rather than 1 year. R. A. Imm pointed out that history was troublesome in new rapidly advancing areas with new members and that forecasting was the best method of determining quotas in these areas.

Wear Your ◆ AIEE Badge

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until December 29. Duplicate double spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, AIEE, 33 W. 39th St., New York 18, N. Y., on or before December 29.

58-1143 **A Character-Metered Transatlantic Switching System.** *I. S. Coggeshall, P. Holcomb, Jr.*

59-131 **Synthesis of Induction Motor Designs on a Digital Computer.** *C. G. Veinott*

59-204 **Matrix Algebra of Sequential Logic.** *E. J. Schubert*

59-205 **Symmetric Switching Functions (Matrix Logic V).** *E. J. Schubert*

59-223 **Saturable Reactor Control of Full-Wave and Biphase Rectifiers.** *J. B. Thomas, J. W. Drenning*

59-234 **Power Relationships and Temperature Dependence in the D-C Corona Field.** *J. B. Thomas, T. R. Williams, T. Suzuki*

59-259 **A Military 4-Wire Field Telephone Incorporating an Electronic Signaling System.** *J. L. Faherty, A. S. Howell*

59-261 **Back-Transient Diode Logic.** *G. Wolff*

59-567 **Dynamic Circuit Theory.** *H. K. Messerle*

59-1139 **Analysis of Series Generator Series Motor Drive.** *R. W. Jones, A. U. Meyer*

Preprints may be purchased at 50¢ each to members, $1.00 to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y.

Army Secretary Brucker Will Speak at Conference

Secretary of the Army W. C. Brucker has accepted an invitation to address the National Conference on the Application of Electrical Insulation in Washington, D. C., on December 8, 1959, it was announced by the organizing committee. Secretary Brucker will deliver the principal address at the "Unity of Action" banquet to be held in the Sheraton-Park Hotel.

Harold Boeschenstein, president, Owens-Corning Fiberglas Corporation, of Toledo, Ohio, will be toastmaster on that occasion.

Keynote of the banquet will be the vital role which electrical insulation plays in the space age, and the importance of unity of action to maintain national objectives in this rapidly changing era of technology. At that time, a "Golden Omega Award" will be presented to one of America's leaders in science and engineering. The award, which is not limited to any particular field, is sponsored by Lake Publishing Corporation of Libertyville, Ill., publishers of *Insulation* magazine.

Varied activities of the conference will extend from December 7 through December 11, with sessions and exhibits at the Shoreham Hotel. Attendance of about 2,500 persons in industry, research, and Government is expected. This will be the second national conference. The first was held in Cleveland, Ohio, in 1958.

It was also announced that more than 100 firms have already contracted for exhibit space. In addition, there will be Government and technical exhibits. Technical sessions will be held on December 8, 9, and 10, running simultaneously in three sections—one on distribution equipment, one on rotating machinery, and one devoted to electronics. More than 85 papers will be delivered. A marketing conference on December 7 will precede the conference. Many of the participants will visit industrial and defense installations in the Washington-Baltimore area on Friday, December 11.

DUE FOR COMPLETION late in 1960, the new building for Cooper Union's School of Engineering (left) is shown in this architect's sketch. Voorhees, Walker, Smith, Smith, and Haines are the architects. In the engraving (above), Cooper Union is depicted as it stood around the year 1860. For 100 years, Cooper Union has offered college instruction free of tuition charge and has expanded its accredited courses in the fields of science, engineering, architecture, and design.

Cooper Union Marks 100th Year

Delegates of about 300 educational institutions and societies marched in an academic procession that opened an all-day convocation on Monday, November 2, 1959, marking the 100th anniversary of the Cooper Union for the Advancement of Science and Art.

Some of the oldest institutions in the western world were represented in procession, including Oxford University, founded in 1249, A. D.; the Vatican Library, 1450; the University of Santo Domingo, 1538; and Harvard University, 1646.

Sessions following throughout the day included lectures by Nobel Prize winners and other authorities on the general theme, "New Values in Science, Art, and Society."

An academic convocation, starting at 10:30 a.m. in the Great Hall, was attended by the institutional delegates and by an estimated audience of more than 1,000 Cooper Union students and faculty and invited guests. Dr. M. L. Gould, president of Carleton College, spoke on "Education and Society," and Dr. C. V. Newsom, president of New York University, brought greetings from the educational institutions throughout the academic world.

In the afternoon, two sessions were held in the Great Hall. Sir Kenneth Clark, art critic and historian and chairman of the Arts Council of Great Britain, spoke on "Art and Society," Two recipients of Nobel Prizes—Sir John Cockcroft, British physicist of the United Kingdom Atomic Energy Authority; and Dr. M. C. Urey, American scientist now at the University of California—shared the second session in a discussion of "Science and Society."

A centennial dinner for delegates and invited guests was held at 7:15 in the Grand Ballroom of the Waldorf-Astoria, where an address on "Government and Society" was given by L. B. Pearson, member of the Canadian House of Commons, recipient of the Nobel Prize for Peace, and former president of the General Assembly of the United Nations.

The centennial program marked formal opening of the Cooper Union on the evening of November 2, 1859. At that time, Peter Cooper announced the beginning of free courses on the college level in science and art, the first free program of higher education ever offered in this country under private sponsorship. At the same time, he announced a series of free public lectures in the Great Hall, marking the beginning of one of America's earliest experiments in free adult education.

Undergraduate enrollment now numbers about 1,300 young men and women, who have been selected for intellectual ability alone, without regard for race, creed, sex, or economic status. Its evening Forum programs attract audiences averaging about 1,000 persons, three times a week.

In connection with its centennial observance, which will continue through the academic year of 1959-60, the Cooper Union has started a development program, of which the first step is the construction of a new building for the School of Engineering. The structure is now well under way and is expected to be occupied during the academic year of 1960–61.

Among thousands who apply for admission to the Cooper Union's School of Engineering, only 200 are accepted each year as students. These 200, having ranked highest in the entrance examinations, which measure intelligence and professional aptitude, are given 4 tuition-free years in a private college that has turned out some of America's great creative engineers and scientists.

There are 725 students enrolled this year in its day and evening sessions, each on a scholarship which requires only that the student maintain a good average to get a degree in either civil, electrical, mechanical, or chemical engineering.

"If we compare the average College Entrance Examination Board scores of its 1959 day freshman class with a comparison standard representing all high school seniors," said N. L. Towle, dean of the Cooper Union School of Engineering, "we find all of the Cooper Union class in the top 10% of the high school seniors and nearly 2/3 of them (62%) in the top 2% of the high school senior average."

In a survey sponsored by the Ford Foundation, Cooper Union's School of Engineering showed up third among the nation's exclusively technical schools in the production of scholars, said Dean Towle. Only the Massachusetts Institute of Technology and California Institute of Technology produced a higher proportion of doctorates and fellowship winners. The leadership of Cooper Union is further emphasized by the fact that in the survey it ranks first among the exclusively undergraduate technical schools, he pointed out. The two great institutions ahead of Cooper Union are noted primarily for their emphasis on graduate study and research, he declared.

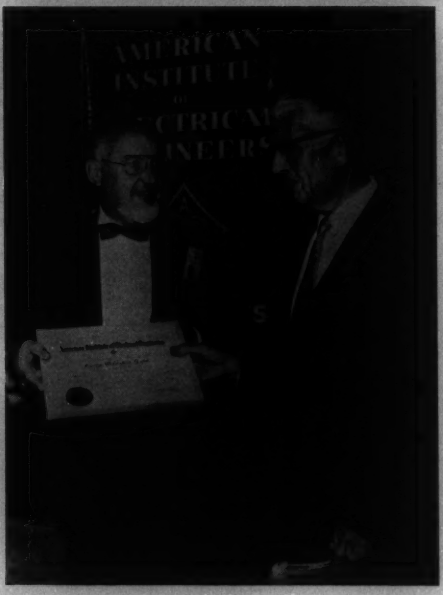
"A report of the Office of Scientific Personnel of the National Research Council," added Dean Towle, "shows that in the period 1936-56, Cooper Union had 98 graduates who obtained the degree of

doctor of philosophy. While the national ratio for all colleges in the United States is 26.7 per thousand graduates, Cooper Union's ratio is 39 per thousand for the combined day and evening engineering school, and 66 per thousand for the day school alone."

"When Peter Cooper opened the doors of Cooper Union a century ago," remarked Dean Towle, "he set the standard of attainment at equal to the best." Expansion of facilities and periodic revision of curriculum offerings through the years have kept the Cooper Union School of Engineering in a position of leadership in the field of engineering education.

"Construction of a new building for the school which is scheduled for completion in 1960 will make it possible for Cooper Union to maintain its recognized standing among technological schools. It will be equipped with modern facilities especially designed to encourage a close student-teacher working relationship in classroom study and laboratory research, and enable us to keep apace with the engineering developments of the rapidly advancing space age."

Among the outstanding men who got their start in engineering at Cooper Union are Michael Pupin, inventor, electrical engineer and scientist, and David Steinman, builder of the 5-mile-long Mackinac Bridge.



THE DC-8 jetliner (above photo)—From Development to Commercial Service—was discussed by Harry Hjorth of Douglas Aircraft Company at the October dinner meeting of the Los Angeles Section. Standing beside the model airplane are: (*left to right*) Prof. L. L. Grandi, Section secretary-treasurer; Fred Foulon, chairman; Robert Milmoe, vice-chairman; and Mr. Hjorth. The AIEE Fellow diploma (*photo at left*) was accepted by G. W. Downs (*left*) of Dynamics Instrumentation Company, from L. F. Hunt (*right*), director of electrical engineering, Ralph M. Parsons Company, Los Angeles, Calif.

Stuart Photos

Los Angeles Section Hears About New Jetliner

Five million dollars was the price quoted for the new Douglas *DC-8* Jet Airliner at the AIEE Los Angeles Section's general session on October 13.

No orders were taken at the dinner meeting but more than 200 members, students, and guests were attentive as the speaker, Harry Hjorth, told of the giant *DC-8* Jet Transport, "From Development to Commercial Service." For the past 4 years, Mr. Hjorth has been assistant chief project engineer for the *DC-8*. He attended the University of California at Los Angeles and the California Institute of Technology and has been with the Douglas Aircraft Company for more than 20 years.

Using color slides, Mr. Hjorth gave technical data on the various systems and controls, performance capabilities, and interior layouts of the cockpit and cabins. A sound and color motion picture of the completed airplane on the ground and in flight gave visible evidence of the magnificent design and engineering throughout.

Two awards further highlighted the evening. G. W. Downs, divisional director of Dynamics Instrumentation Company, South Pasadena, Calif., and vice-president, Applied Physics Corporation, Monrovia, Calif., was presented with his AIEE Fellow diploma, given "for his contributions to refinement of acoustical and data-evaluating apparatus and systems." E. D. Barcus, junior past chairman, Los Angeles Section, received his Past Chairman Award for "outstanding service to the Section and achievement during 1958-59." Mr. Barcus is toll service transmission engineer with the Pacific Telephone Company in Los Angeles, Calif.

100 Chapters Represented At Tau Beta Pi Convention

Tau Beta Pi's 54th National Convention was held at Purdue University, Lafayette, Ind., October 15–17, 1959. The Indiana Alpha chapter at Purdue was official host. One hundred active collegiate chapters of the association were represented at the session. The convention was also attended by Tau Beta Pi's national officers.

The convention, headquartered at Purdue's Memorial Union, consisted of four business meetings, several specially arranged discussion sessions, and two banquet programs of particular interest.

The convention granted a new chapter

of Tau Beta Pi to the local engineering honor society at Southwestern Louisiana Institute, Lafayette, La., which had submitted a petition for a charter last winter. The new chapter, to be Louisiana Delta, will be installed this coming winter as the association's 103rd active undergraduate group.

A special program feature at the luncheon on October 16 was an address by Merwin Brandon (AM '28, F '44), president, of Underwriters' Laboratories, Inc., Chicago, Ill., and a member of Tau Beta Pi. Mr. Brandon spoke on "The Engineer and Free Enterprise."

A major event of the convention was the initiation and banquet on Friday evening, October 16. The initiation ceremony was conducted by a group of officers of Tau Beta Pi. The ceremony brought into membership in the association 80 students of Purdue and four professional men including Prof. Rufus Oldenburger (M '55) of Purdue and C. H. Linder (M '54, F '57), vice-president for engineering of the General Electric Company. Mr. Linder delivered the major address on the after-dinner program.

Another feature of the initiation banquet program was the announcement and presentation of the winners of the Outstanding Chapter Awards for 1958-59. Top prize in this competition went to the Texas Alpha chapter at the University of Texas, and an honorable mention was given to Louisiana Gamma at Louisiana Polytechnic Institute.

On October 17, Dean H. L. Hazen (AM '26, F '43) of the Massachusetts Institute of Technology and Prof. H. A. Foecke (AM '56) of the University of Notre Dame gave talks on the pressing need for qualified engineering teachers in the next decade. They stressed that the coming flood of students to the nation's engineering colleges, plus the normal loss of faculty through retirement over the next 10 years, will require the recruitment of 10,000 new teachers. They led a discussion among the convention delegates on financial aids for graduate study, means of securing teaching experience, and the work that Tau Beta Pi chapters might do to encourage qualified engineering students to consider aiming toward college teaching careers.

The convention voted to hold the 1960 national meeting in October at Lehigh University with the Pennsylvania Alpha chapter there as official host. Next year will mark Tau Beta Pi's 75th birthday, and the 1960 meeting will be designated the Diamond Anniversary Convention.

Valuable feaures of Tau Beta Pi conventions are the chapter-work discussions and the exhibits at which ideas for school and community service projects and chapter administration are exchanged by the delegates, most of whom are presidents of their local groups.

They discussed a program of co-operation between the student group and the Rochester alumnus chapter of Tau Beta Pi which includes career counseling and achievement awards for students. This discussion was arranged by M. V. Burggraaf (AM '50), Tau Beta Pi's alumni representative.

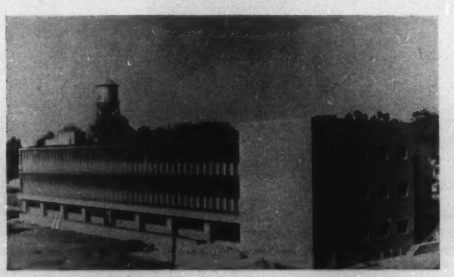
Tau Beta Pi is a national engineering honor society which was founded at Lehigh University, Bethlehem, Pa., in 1885. It now has 102 active undergraduate chapters in United States engineering colleges, 27 alumnus chapters, and more than 102,000 initiated members. Students are elected to membership by the chapters from the top 20% (scholastically) of their engineering classes on the basis of character and service to their colleges. Alumni may be elected on the basis of their eminent profession.

Industrial Motors Studied

A STUDY COURSE covering the application and the control of industrial 3-phase motors was presented in eight weekly sessions by the Michigan Section, AIEE. The sessions, which started October 1, 1959, were held at the Detroit Edison Company Sales Auditorium. Topics for the sessions, conducted by authorities in this field, included: Theory and Characteristics of Induction Motors; Starting and Control of Induction Motors; Theory, Characteristics, and Control of Synchronous Motors; Motor and Control Standards; Inspection and Maintenance; Motor Protection; Motor Controllers; Motor Applications. Burkhard Schneider (*standing*), chairman of the Michigan Section, addressed the opening session of the study course.

MSM Dedicates New Million-Dollar Building

Dedication ceremonies were held November 7, 1959, for the new million-dollar electrical engineering classroom and laboratory building on the campus of the Missouri School of Mines and Metallurgy (MSM) at Rolla, Mo. Principal speaker at the dedication ceremony was Dr. J. H. Foote, AIEE president. Others taking part in the dedication ceremony were: Dr. Elmer Ellis, president of the University of Missouri; Dean C. L. Wilson, dean of the School of Mines and Metallurgy; and Alan Hoener, a member of the architectural firm of P. John Hoener and Associates who designed the building. The classrooms, laboratories,



AN EXTERIOR VIEW is shown of the new million-dollar electrical engineering classroom and laboratory building on the campus of the Missouri School of Mines and Metallurgy.

and offices of the new building were open for inspection by visitors on the dedication day.

Funds for the construction of the new electrical engineering building were allotted from the $75 million bond issue for Missouri's state institutions which passed in 1956. Contracts for the construction of the building were awarded in March 1958, and ground was broken in April 1958. The electrical engineering department moved all classrooms, offices, and electronic laboratories into the new building at the beginning of the fall semester in September 1959. The electrical machinery laboratories were moved later.

The electrical engineering department is the second largest department at MSM having a total enrollment of 642 students; 210 freshmen, 115 sophomores, 168 juniors, 135 seniors, and 14 graduate students. The department staff headed by Prof. I. H. Lovett, department chairman, numbers 22, including 5 professors, 2 associate professors, 3 assistant professors, 10 instructors, and 2 graduate assistants.

AAAS Schedules Section M Engineering Program

The American Association for the Advancement of Science (AAAS) will hold its 126th annual meeting December 26-31, 1959, at Hotel Morrison, Chicago, Ill. Two days of this meeting, December 28-29, will be devoted to the Section M Engineering Program on the topic, "National and International Aspects of Systems of Units." The subheading of this topic is "Operation SCUDS: Simplification, Clarification, Unification, Decimalization, and Standardization."

The tentative listing of the Section M Engineering Program follows:

Monday, December 28

Morning Session

The Confusion of Chaos in Units

Presiding: C. F. Kayan

International Viewpoint of an American Engineer on Units. *W. L. Cisler*, president, American Society of Mechanical Engineers.

Should American Industry Convert to the Metric System? Summary of Views Recently Expressed by Industry. *G. F. Hussey, Jr.*, managing director, American Standards Association.

Our Units of Weights and Measures. *L. V. Judson*, Office of Weights and Measures, National Bureau of Standards.

International Challenge to American Education and its Relationship to the Unit System. *J. J. Theobald*, superintendent of schools, New York, N. Y.

Farmers' and Grain Processes—Unit Simplifications. *Hamill Varner*, manager, grain purchasing department, Quaker Oats Company.

The Chaos in Consumer Goods Packaging. *C. E. Warne*, president, Consumers Union.

Afternoon Session

Public Education vs. the Consumer Public

Presiding: H. C. Diehl

Decimalization in the Schools. *J. H. Smith*, associate superintendent of instruction, Board of Education, Chicago, Ill.

Children vs. Decimals and Other Fractions. *Lore Rasmussen, D. A. Page*, University of Illinois Arithmetic Project.

Food Container Standardization and the Public Interest. *Howard Stier*, National Canners Association.

Packaging Identification and Marking. *A. C. Beardsell*, director of New Products Division, Mead Corporation.

Common Fractions vs. Decimals in Stock Exchange Reporting. *R. M. Bishop*, special assistant to the president, New York Stock Exchange.

Tuesday, December 29

Morning Session

Problems of Design, Manufacture, and Commerce

Presiding: R. J. Painter

An Investigation of the Effect of Foot Decimalization on Building Design and Construction Processes. *P. C. Smith*, architect, Voorhees, Walker, Smith, Smith, and Haines.

Measuring Units for the Textile Industry—Present and Prospective. *A. D. Scroggie*, textile fibers department, E. I. duPont de Nemours & Co. Inc.

English and Metric Systems of Measurements in the Forest-Products Industries and their Effect on Manufacturing and Construction Practices. *A. J. Panshin*, head department of forest products, Michigan State University.

Machine Tools and the Inch–Meter Conversion. *H. S. Sizer*, director of design, Machine Tool Division, Brown and Sharp Manufacturing Company.

Weighing with Decimals. *R. E. Bell*, chief engineer, Toledo Scale Division, Toledo Scale Corporation.

Pro's and Con's of the Weighing Problem vs. Decimal and Metric Changeover. *C. G. Gehringer*, manager, M-Scale Division, Fairbanks, Morse and Company.

Afternoon Session

The Look to the Future

Presiding: C. E. Davies

The Decimal Idea in Handling Units. *C. D. Leake*, president-elect, AAAS.

Progress Report on the Changeover Problems for Great Britain. *A. H. Hughes*, deputy chairman, British Association Metric Committee.

Status of NBS Study–Project on Ways and Means to Accelerate Metric Changeover in the U.S.A. *A. V. Astin*, director, National Bureau of Standards.

Impact of the Multiplicity of Technical Disciplines on Unit-System Usages. *Guy Waddington*, Office of Critical Tables, National Academy of Sciences–National Research Council.

Accelerated Progress in the Automotive Decimalization Program. *R. P. Trowbridge*, GM Engineering Standards, General Motors Corporation.

Parke-Davis Adopts the Metric System. *D. G. Neill*, manager, materials handling department, Parke-Davis Company.

Highlights of the Special AAAS Report on Metric Usage. *Wilmer Souder*, chairman, AAAS Committee on Metric Usage.

Conference on Engineering Manpower

On Monday, December 28, in the Hamilton Hotel, morning and afternoon, six leaders of engineering and science will discuss "Higher Education in Emerging Fields of Science and Technology."

Details will be in the program for the meeting.

Automotive Styling Featured

MAIN SPEAKER at the October dinner meeting of the Michigan Section, AIEE, was John Najjar, executive stylist for the Ford Motor Company, who discussed the evolution and problems of automotive styling. Pictured here are: (*left to right*) Robert Albrecht of Consumers Power Company, program chairman; Mr. Najjar; and Burk Schneider, chairman of the Michigan Section.

The Great Lakes Basin

In the Mirror Room, Hamilton Hotel, Tuesday morning and afternoon, December 29, and Wednesday morning, December 30, Section M (Engineering) is joining in sponsoring three sessions with 20 speakers on the Great Lakes Basin. The engineering treatments will deal with navigation, power, transportation, water utilization, beach erosion, and water supply.

The details can be found in the program for the meeting, secured in advance from AAAS at 1515 Massachusetts Ave., N.W., Washington, D.C., by payment of a $3 fee, or at the meeting by registration at the Morrison Hotel.

AAAS Meeting Features

One of the characteristically dramatic features of AAAS meetings is the list of addresses by distinguished authorities.

Details about specific times and places for these affairs may be found in the program for the meeting.

Following is a list by dates of these important events:

Saturday, December 26

Evening Session

Moving Frontiers of Science IV

How Did Life Begin. *S. W. Fox*, Oceanographic Institute, Florida State University.

How Artificial Satellites Can Help Scientific Research. *W. H. Pickering*, Jet Propulsion Laboratory, California Institute of Technology.

Sunday, December 27

Afternoon Session.

Moving Frontiers of Science IV

Elementary Particles of Modern Physics. *R. E. Marshak*, department of physics and astronomy, University of Rochester.

Genes, Viruses, and Cancer. *W. M. Stanley*, Biochemistry and Virus Laboratory, University of California.

Evening Session

Tau Beta Pi Lecture. *T. K. Glennan*, administrator, National Aeronautics and Space Administration.

Monday, December 28

Evening Session

AAAS Retiring Presidential Address. *W. R. Brode*, science adviser, Department of State.

Tuesday, December 29

Evening Session

Society of Sigma Xi and the United Chapters of Phi Beta Kappa. *L. A. DuBridge*, president, California Institute of Technology.

Wednesday, December 30

Evening Session

National Geographic Society's Illustrated Lecture on Maya Ruins in Yucatan. *E. W. Andrews*, associate in archaeology, Tulane University.

AIEE FELLOWS ELECTED

Board of Directors Meeting, October 16, 1959

Edwin Charles Ballman (AM '24, M '45), chairman of the board, Baldor Electric Company, St. Louis, Mo., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to design and fabrication of small electric motors." He was born August 22, 1883, in St. Louis, Mo., and received the B.S. degree in electrical engineering from Washington University in 1906. During 1906-13, he was employed by the Wagner Electric Company as an experimental engineer, assistant transformer design engineer, and then instrument design engineer. In 1913, he organized the St. Louis Electrical Works where he was chief engineer and vice-president, and manufactured a patented rectifier, ball bearing electric motors, and other electrical devices. He sold this company in 1920 and formed the Baldor Electric Company, of which he was president until 1959. He is presently chairman of the board. He was responsible for developing and making available to the electrical industry many novel products and processes and has 50 patents to his credit.

Todd Studios

E. C. Ballman

Randolph Williams Burrell (AM '35, M '42), senior engineer, Outside Plant Bureau, Consolidated Edison Company of New York, Inc., New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions in the field of power cable engineering and soil thermal resistivity research." He was born in Millwood, N. Y., on April 26, 1905. Mr. Burrell attended Rensselaer Polytechnic Institute, received the electrical engineering degree in 1925 and, under a graduate fellowship, the Eng.D. degree in 1928. Prior to this, he worked summers for the New York Edison Company (1924-26) and the General Railway Signal Company (1927). In 1928, he was employed in the railway engineering department of the General Electric Company. In 1929, he joined the New York and Queens Electric Light and Power Company and, following the absorption of this subsidiary in 1937, has been associated with the Consolidated Edison Company of New York, Inc. His work has included transmission and distribution planning in earlier years and for the past 15 years has been in the field of power cable engineering. He was an instructor during 1931-33 in the New York Edison School and, in 1934-38, taught electrical engineering in the Cooper Union Evening Engineering School. In the field of power cable engineering, he has directed laboratory and field studies to establish basic information regarding electrical and thermal characteristics of power cable systems, including industry-sponsored studies, and has been the author or coauthor of various technical papers reporting on these studies. He has initiated methods for improving the economical application of power cable in the transmission and distribution field. Dr. Burrell is a member of Sigma Xi and of the New York State Society of Professional Engineers. He serves on the AIEE Insulated Conductors Committee (1955-60) and has been chairman of Subcommittee No. 14 which is supervising an industry-wide research study, carried out at the Soil Physics Laboratory of Princeton University, to investigate the thermal resistivity characteristics of soils.

R. W. Burrell

Joseph Stuart Johnson (AM '37, M '43), professor of electrical engineering and dean of the College of Engineering, Wayne State University, Detroit, Mich., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to engineering education." He was born May 8, 1912, in Gower, Mo. He studied electrical engineering, received his B.S. degree in 1932 and his M.S. degree in 1934, both from the University of Missouri, and was awarded the Ph.D. degree from Iowa State College, now Iowa State University. During 1934-36, Dr. Johnson was a graduate teaching assistant, and, in 1936-37, an instructor at Iowa State College. He was instructor and assistant professor of electrical engineering at Missouri School of Mines and Metallurgy in 1937-44, assisting also in the several defense and war training programs assigned to that institution. In 1944, he was commissioned lieutenant junior grade,

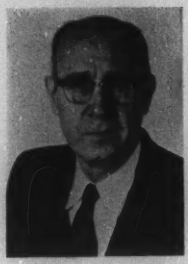
J. S. Johnson

U. S. Naval Reserve. He took preradar training at Bowdoin College and radar training at the Massachusetts Institute of Technology. In 1945, he was assigned as electronics officer in the Far East serving as staff officer for naval electronics activities in the Japanese area and was promoted, in 1946, to lieutenant senior grade. In June 1946, he was appointed by the University of Florida as associate research engineer for the supervision of electrical engineering research, and, in 1947, he was promoted to professor of electrical engineering and assistant dean of engineering, a position he held until 1954. He then moved to Lafayette, Ind., to become head of the School of Electrical Engineering at Purdue University. In 1957, he was named dean of the College of Engineering at Wayne State University, Detroit, Mich. He is a senior member of the Institute of Radio Engineers, a member of the American Society for Engineering Education, the Michigan Engineering Society, the Engineering Society of Detroit, Eta Kappa Nu, Sigma Xi, and Tau Beta Pi. He is a registered professional engineer of the State of Indiana. He has served as AIEE student branch counselor, Missouri School of Mines (1939-43); chairman of AIEE student branch counselors, Southwest District (1940-41); vice-chairman, AIEE Central Indiana Section (1956-57); and as a member of AIEE Committees, as follows: Education (1955-58); Research (1955-58); Fortescue Fellowship (1956-60); and Basic Sciences (1956-58).

Walter Kavanagh MacAdam (M '49), assistant chief engineer, American Telephone and Telegraph Company (AT&T), New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to the growth and improvement of telephone communications." Born November 16, 1913, in New York, N. Y., he received both his bachelor's and master's degrees in electrical engineering from the Massachusetts Institute of Technology. After graduation in 1937, he joined the long lines department of AT&T, working on various engineering assignments in the South. In 1942, he was transferred to the operation and engineering department in New York where he worked in the Inductive Co-ordination Group. In 1949, he headed this group which dealt with interference problems resulting from railroad and utility power systems, lightning protection, and corrosion. In 1951, he headed another group in the Plant Extension Section, responsible for setting up nationwide dialing plans for operator and customer dialing of intercity calls, and then returned to the long lines department as division plant superintendent in Denver, Colo. Following this assignment, he joined the Western Electric Company in 1953, heading the engineering force in charge of constructing the initial stations for the Arctic radar line known as the Distant Early Warning System. He then returned to the long lines department as area chief engineer at White Plains. In March 1956, he was appointed transmission engineer of the AT&T operation and engineering department, a position he held until July 1959 when he was appointed building and equipment engineer. In October 1959, he was appointed assistant chief engineer of AT&T. His duties include the supervision of engineering functions associated with radio, wire, and other means of transmission, outside plant engineering, and the engineering aspects of data transmission, teletypewriter, and other nonvoice services. Mr. MacAdam is a senior member of the Institute of Radio Engineers, a member of Tau Beta Pi, and Sigma Xi. He has served on the following AIEE Committees: Electronic Power Converters (1949-51); Wire Communications Systems (1956-60); Data Communication (1957-60, chairman 1959-60); Professional Conduct (1957-60, vice-chairman 1959-60); and Standards (1957-60).

W. K. MacAdam

Willard Robert McCarty (AM '37, M '45), supervisor of electrical engineering, department of research and development, Wagner Electric Corporation, St. Louis, Mo., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to techniques of high-voltage and corona tests of power transformers." Born in Carmi, Ill., on October 24, 1903, he was graduated from the University of Illinois in 1927 with a B.S. degree in electrical engineering. He was employed by the Wagner Electric Corporation as an electrical engineer in the transformer department where he designed small distribution transformers and gradually expanded into larger ratings until about 1940 when he took charge of design of all distribution transformers, including air-cooled, potential, and monocyclic square constant current transformers. He did research work on many components that led to improvement in the manufacturing and developing of distribution and power transformers. Since 1933, he has had charge of a 2-million volt and later a 3-million volt impulse generator, by use of which research and testing was done on insulation structures, bushings, arresters, and transformers from which new knowledge was gained for the improvement in new high-voltage designs. He was promoted to supervisor, in 1947, of all electrical engineering of distribution transformers and small air-cooled transformers. In 1956, he was promoted to supervisor of electrical engineering of the research and development department and was also placed in charge of the high-voltage laboratory. Work was done which contributed to the techniques of high-voltage testing and corona tests of high-voltage transformers. Mr. McCarty is a registered professional engineer in the State of Missouri. He has been a member of the AIEE Dielectric Test Subcommittee since 1948 and is also serving on the subcommittee for writing an impulse test guide.



W. R. McCarty

Asa Herbert Myles (AM '38, M '45), chief engineer, Electric Controller & Manufacturing Division, Square D Company, Cleveland, Ohio, has been transferred to the grade of Fellow in the AIEE ". . . for contributions by invention and development of electrical controls for heavy industry." Born in LaRue, Ohio, on August 21, 1906, he received his B.S. degree in electrical engineering from Ohio University in 1929. In 1929-30, he was employed by the State of Ohio supervising the installation, construction, and maintenance of state-operated facilities in the Cleveland area. In 1930, he joined the Electric Controller & Manufacturing Company and, until 1935, was assigned to the electrical drafting and design sections. In 1935-43, Mr. Myles was a control engineer responsible for the design and satisfactory operation of

The Hoods

A. H. Myles

heavy duty industrial controls for the steel, chemical, petroleum, mining, rubber and plastic, and allied industries. In 1943, he was made assistant chief engineer in charge of control engineering, drafting, test, and service sections of the company. In 1956, following the merger with Square D Company, Mr. Myles was promoted to chief engineer of the Electric Controller & Manufacturing Division, responsible for the design and engineering of new products and new systems, and the redesign and improvement of existing products and systems, direct and co-ordinate control engineering, service and engineering policies. He is a member of the National Electrical Manufacturers Association, the Association of Iron and Steel Engineers, and the Iron and Steel Institute of England. He has served on the AIEE Industrial Control Committee (1950-60) and Metal Industry Committee (1958-60).

Alfred Leon Pollard (M '40), operating manager, Puget Sound Power & Light Company, Bellevue, Wash., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to development and operating management of a large electric utility." Born May 17, 1893, in Westboro, Mass., he studied mechanical engineering at Wentworth Institute, Boston, Mass., and graduated in 1915. Upon graduation, he was employed by Stone & Webster as a student engineer, assigned to the Houghton County Electric Light & Power Company, Houghton, Mich. In 1917-19, he served as a second lieutenant in the U. S. Army air service. Following World War I, he became maintenance engineer of the Blackstone Valley Gas & Electric Company, Pawtucket, R. I. In 1920, he was transferred by Stone & Webster to the Nova Scotia Tramway Power Company at Halifax, Nova Scotia, as assistant chief engineer. His next assignment took him to El Paso, Texas, where he was an assistant chief engineer for the El Paso Electric Company in charge of maintenance and operation of a 34,000-kw steam plant and two transmission substations. Following that, he served 2 years as assistant chief engineer of the Tampa Electric Company. He then moved to Boston where he was power engineer for Stone & Webster Engineering Corporation, supervising construction and operation of steam-electric plants. He moved to the Far West in 1930 to become superintendent of the Steam Division for Puget Sound Power & Light Company. In 1932, while retaining responsibility for the thermal generation and steam heat activities, he also became assistant general superintendent of the light and power department, Central District. Here, his duties had to do with substation, overhead, underground, and meter department operations. He was advanced, in 1935, to general superintendent, light and power department, Central District. The following year, he became general superintendent of light and power, Executive Office. This position gave him responsibility for electrical construction, operation, and maintenance for the entire Puget Sound Power & Light Company. In that year, he qualified as both a mechanical and electrical engineer in the State of Washington. He became operating manager for the company in 1950, extending

Walters Studio

A. L. Pollard

his responsibilities to include all engineering, operating, and purchasing. By 1953, the need for additional generation became evident, and he turned his administrative and technical talents to the economic solution of that problem. The result is the Upper Baker River Project, at 94 mva, the largest automatic hydroelectric plant in the Pacific Northwest. He has served on the AIEE Power Generation Committee (1947-57).

Ralph Emerson Thornton (M '32), superintendent of engineering, Oklahoma Gas and Electric Company, Oklahoma City, Okla., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to planned expansion of a utility power system." Born April 29, 1903, at Keokuk Falls, Indian Territory, which is now Oklahoma, he received the B.S. degree in electrical engineering from the University of Oklahoma in June 1925. While at the University of Oklahoma and during summer vacations, he worked part-time for the Oklahoma Gas and Electric Company and became a full-time employee upon graduation. He spent a year in the general office engineering department and was transferred in July 1926 to the Central Division with headquarters at Sapulpa. He was made division engineer of the Central Division in January 1927 and remained in that position until July 1935, when he was transferred to Fort Smith, Ark., as Arkansas Division engineer. He remained there until November 1941 and was then transferred to the general office in Oklahoma City as chief distribution engineer, a position he held until he was called into the Army in July 1943. He served in the Engineering Corps in the

R. E. Thornton

Arctic on the construction, operation, and maintenance of Arctic air bases. The last 18 months were spent at Goose Bay, Labrador. In March 1946, he returned to his position as distribution engineer and remained there until November 1946, when he was superintendent of engineering. In September 1950, he returned to the Armed Service as commander of a reserve Engineer Construction Battalion, trained at Camp Carson, Colo. When the training was completed, he became executive of the post engineer installation at Fort Riley, Camp Funston, and Camp Forsythe, Kans. He was transferred to St. Louis, Mo., as post engineer of the St. Louis Medical Depot and staff engineer for the commanding general of the Missouri Military District. Upon release from active military duty in August 1952, he returned to Oklahoma Gas and Electric Company as superintendent of engineering. He is a registered professional engineer in the State of Oklahoma, and a member of Scabbard and Blade, Eta Kappa Nu, the National Society of Professional Engineers, the Oklahoma Society of Professional Engineers, the Society of Military Engineers, and the Reserve Officers Association. He has served on the following AIEE Committees: Transmission and Distribution (1952-60); System Engineering (1953-54); and Petroleum Industry (1954-56).

Harold Torgersen (AM '31, M '39), professor of electrical engineering and dean, School of Engineering, University of Connecticut, Storrs, Conn., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to engineering education." He was born in Brooklyn, N. Y., on January 2, 1910, and received the B.S. degree in electrical engineering, cum laude, from New York University (NYU) in 1929. After working briefly for the General Electric Company, he became instructor of electrical engineering at NYU in 1930. He was granted a leave of absence to spend a year in full-time graduate study at Harvard University, where he received the M.S. degree in engineering in 1939. He returned to NYU as assistant professor of electrical engineering and participated in the development of the graduate program. In 1941, he was called to active duty as a lieutenant junior grade in the Naval Reserve and was assigned to teach at the Naval Academy. In 1945, he was appointed head of the electronics department of the Naval Post-graduate Communications School and was discharged from active duty in 1946 with the rank of Commander, USNR. He rejoined the faculty of NYU as associate professor of electrical engineering and assistant director of the Evening Division of the College of Engineering. Subsequently, he became assistant dean in charge of the Evening Division and professor of electrical engineering. In 1952, he was appointed assistant dean of the College of Engineering, and, in 1954, he became associate dean. During 1952-53, he also served as acting chairman of the department of electrical engineering. He contributed to the development of a new program at NYU in the humanities and social studies for engineering students and to the establishment of a curriculum in engineering science. He also participated in the development of the graduate pro-

U Conn Photo
Harold Torgersen

gram conducted by NYU at Bell Telephone Laboratories in Murray Hill, N. J. In 1957, he was appointed professor of electrical engineering and dean of the School of Engineering at the University of Connecticut. Under his administration, a graduate program in nuclear engineering has been established and the graduate programs in other fields of engineering have been expanded to the doctoral level. He is a member of the Institute of Radio Engineers and a member of the American Society for Engineering Education where he is currently chairman of the Manpower and Military Affairs Committees. He has served on the Engineering Manpower Commission. He is also a member of Eta Kappa Nu, Pi Tau Sigma, Tau Beta Pi, the Connecticut Society of Civil Engineers, the Harvard Engineers Club, and the Harvard Club of New York City.

Walter Raymond Wilson (AM '43, M '48), manager of engineering, high-voltage switchgear department, General Electric Company (GE), Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for contributions to development of high-voltage switchgear." Born in South Bend, Ind., on May 3, 1919, he received the B.S. degree in engineering physics from the University of Michigan in June 1941. He joined GE in June 1940, working in the Detroit Service Shop and has remained with GE to the present time. In 1941-42, he worked on electric contacts and arcs in the Research Laboratory. During 1942-49, he worked on high-voltage phenomenon in the Electrical Research Section of the Transformer and Allied Products Laboratory at Pittsfield, Mass. In 1949-54, he was manager of the Electrical Section in the Switchgear Products Laboratory, Philadelphia, investigating high current and high-voltage phenomenon. In 1954-56, he was manager, engineering research, switchgear and control laboratories department, Philadelphia. He became manager of engineering, high-voltage switchgear department, in 1956. In 1944, the American Society of Civil Engineers awarded him the Alfred Noble Prize for a paper on corona in aircraft electrical systems. He was a U. S. Delegate to the International Electrotechnical Commission meeting in Madrid 1959. He is a member of the International Conference on Large Electric Systems. He has served on the AIEE Switchgear Committee (1956-60).

W. R. Wilson

AIEE PERSONALITIES

A. H. Belliveau (AM '54) has retired from the Automatic Electric Company, Northlake, Ill., after more than 34 years with the firm. He joined the subsidiary of General Telephone & Electronics in 1925 after reading a book on automatic telephony which had been written by one of the company's engineers. During his long service with the telephone manufacturing company, he served in the receiving, inspection, quality control, and industrial engineering departments, and as accountant, secretary, and technical writer in the laboratory organization. In 1944, he was promoted to the patent department. He became senior patent engineer in 1952. He has been credited with seven patents for the application of telephone-type relays and switches for industrial control and automation uses.

A. N. Curtiss (M '57), former manager of the West Coast missile and surface radar department of the Radio Corporation of America, has been promoted to general manager while the department has been raised to divisional status. He is a member of the AIEE Fortescue Fellowship Committee (1957-60).

H. C. Graves, Jr. (AM '23, M '43), of Delmont, Pa., president of the Gibson Electric Company, has been re-elected chairman of the Industrial Relations Committee, Electrical Contacts Section, of the National Electrical Manufacturers Association. The Section is composed of manufacturers of electrical contacts used in making precision switches for industrial apparatus.

John Gronan (M '54) has been appointed chief project engineer in the nuclear power engineering department of Alco Products, Inc., Schenectady, N. Y. He was formerly associated with the Cunard Line and with the engineering consultant firm of Burns and Roe, Inc.

H. B. Haig (M '47) has retired from the ordnance department, Defense Electronics Division, of General Electric Company, Pittsfield, Mass., after 43 years of service. All of this time was spent in the development, design, and manufacture of fire control equipment for the U. S. Navy. He will continue with the ordnance department as a consultant for the remainder of 1959.

A. S. Hoagland (AM '49, M '57) has been appointed manager of engineering sciences research at the San Jose, Calif., research laboratory of International Business Machines Corporation. He was formerly senior research engineer, responsible for large-scale memory research.

W. D. Olmsted (AM '58) has been named to the switchgear department of Allis-Chalmers Manufacturing Company, Milwaukee, Wis., as an application engineer. He joined Allis-Chalmers in 1958 and had been a sales representative in the firm's Milwaukee district for the last 4 months.

CORRECTION: On p. 967, column 1, of the September issue of *Electrical Engineering*, the position of Robert Paxton was incorrectly implied to be chief executive of the General Electric Company and chairman of the company's Board of Directors. He is now president of General Electric and has over-all responsibility for the company's operating components. He succeeded Ralph Cordiner as president, but Mr. Cordiner currently holds the positions of chief executive of the company and chairman of the Board of Directors.

OBITUARIES

Einer A. Brofos (AM '07, M '18, Member for Life), telephone and radio broadcasting industry pioneer, died recently in Great Barrington, Mass., at the age of 76. A retired vice-president of International Standard Electric Corporation, subsidiary of International Telephone and Telegraph Corporation (ITT), he introduced the first complete radio broadcasting station to the Scandinavian countries at Oslo, Norway, in 1922, and Scandinavia's first automatic rotary telephone equipment. He was also instrumental in establishing ITT factories in Scandinavia. Born December 23, 1882, in Christiania, Norway, he attended Electrotechnical College in Christiania from which he graduated in 1902. In 1900-01, he was shop and installation apprentice for the Elektrisk Bureau of Christiania. During 1903-09, he was equipment engineer for the American Electric Telephone Company of Chicago, Ill. He joined the Western Electric Company as a telephone engineer in New York in 1910 and transferred to the Bell Telephone Manufacturing Company in Antwerp, Belgium, in 1912. During 1914-24, he held various engineering posts in the ITT system, and, in 1924, became ITT's European commercial manager with headquarters in London. In 1939, he moved his headquarters to Norway where he remained throughout

(*Continued on page 1231*)

AIEE Section and Student Branch Meetings 1958-1959

Table I. Section Membership, August 1959; Section Meetings During Year Ending April 30, 1959

Section	AIEE Members August 1959	Number of Meetings	Total Number of Meetings
Akron	261	9	
Group: Power		3	12
Alabama	391	11	
Group: Communications		4	
Subsection: Montgomery		12	27
Arizona	298	11	
Groups: Computer		5	
Electronic and Communications		10	
Industrial		4	
Power		7	
Technical		6	
Joint Meetings: Industrial and Technical		1	44
Arkansas	155	8	
Subsection: Northwest Arkansas		8	16
Arrowhead	76	10	
Groups: Industrial Discussion		6	
Utility Discussion		1	17
Baton Rouge	95	13	13
Beaumont	142	16	
Subsection: Lake Charles		8	
Joint Meeting: Section and Lake Charles Subsection		1	25
Boston	1,266	8	
Groups: Basic Sciences		3	
Computer		2	
Electronic and Communications		5	
Engineering Management		1	
Industrial Systems		3	
Instrumentation		2	
Nucleonics		1	
Utility Systems		2	
Joint Meeting: Nucleonics and Utility Systems		1	28
Canton	115	7	
Groups: Distribution		3	
Power Discussion		3	13
Central Illinois	227	11	
Group: Technical		4	15
Central Indiana	429	9	
Subsection: Evansville		6	15
Chicago	2,273	7	
Groups: Basic Sciences		3	
Communications		3	
Electronics		4	
Industrial		5	
Power		2	
Young Engineers		2	
Joint Meeting: Basic Sciences and Power		1	27
Cincinnati	443	11	
Group: Technical		2	13
Cleveland	1,151	8	
Groups: Analog Computer and Control		4	
Basic Sciences		4	
Communication and Electronics		2	
Digital Computer		6	
Electrical Installations		3	
Instrumentation		6	
Management		4	
Motors and Control		6	
Power Generation and Distribution		5	
Joint Meetings: Electrical Installations and Power		1	
Basic Sciences, Communication – Electronics, Instrumentation		1	50
Columbus	313	11	
Groups: Industrial and Utility Power Systems		2	
Management		5	
Subsections: Chillicothe		4	
Newark		4	
Zanesville		14	
Joint Meetings: Chillicothe and Scioto Valley		2	42
Connecticut	957	8	
Groups: Communications		3	
Electric Controls and Measurement		3	
Electric Power Application		4	
Industrial Electronics		2	
Industrial Power		3	
Management		2	
Subsection: New London		12	37
Corpus Christi	122	12	
Group: Technical		2	
Subsection: Victoria-Port Lavaca		10	24
Dayton	359	4	
Groups: Computer		1	
Industrial Controls		4	
Instrumentation – Nucleonics		3	
Power Discussion		2	
Rotating Machinery		3	17
Delaware Bay	191	13	13
Denver	573	8	
Groups: Aeronautical		4	
Communication and Electronics		3	
Electrical Equipment		4	
Power Systems		4	
Subsection: Black Hills		4	27
East Tennessee	550	26	
Subsections: Huntsville		5	
Muscle Shoals		10	
Tullahoma		9	
Upper East Tennessee		6	56
El Paso	144	12	
Group: Technical		3	15
Erie	241	13	
Groups: Basic Sciences		2	
Computer		4	
Management		1	20
Florida West Coast	440	9	
Group: Phosphate Mining Industries		1	
Subsection: Central Florida		3	13
Fort Wayne	204	9	
Group: Rotating Machinery Discussion		4	
Subsection: Marion		6	19
Georgia	430	10	
Subsection: Rome		8	18
Gulf Coast	159	11	
Subsection: Panama City		4	15
Hamilton	228	10	
Group: Technical		1	
Subsections: Guelph		6	
London		7	
Joint Meeting: Section and Guelph Subsection		1	25
Hawaii	110	13	
Group: Technical		8	21
Houston	454	12	
Group: Industrial Application		3	
Subsection: Freeport		8	23
Idaho	101	11	
Subsection: Southern Idaho		11	22
Illinois Valley	93	10	
Group: Technical		8	18
Iowa	197	9	
Group: Power		1	
Subsection: Siouxland		5	15
Iowa-Illinois	185	7	
Subsection: Cedar Valley		8	15
Ithaca	370	11	
Group: Technical		1	
Subsection: Binghamton Area		14	26
Jacksonville	154	11	
Groups: Power		1	
Technical		3	
Transmission and Distribution		1	16
Johnstown	86	13	
Group: Technical		1	14
Kansas City	427	10	
Groups: Communications		2	
Industrial Power and Petroleum		2	
Power Generation, Transmission, Distribution		3	
Technical		2	19
Lehigh Valley	501	11	
Group: Technical		20	31
Lima	146	10	
Groups: Aeronautical Discussion		3	
Feedback Control		3	
Motors and Controls		4	20
Los Angeles	2,850	6	
Groups: Aircraft Division		6	
Basic Sciences		5	
Communications		25	
Electronics		2	
Industry and Construction		6	
Magnetics		3	
Management		2	
Power		6	
Young Engineers' Division		1	
Subsections: Boulder City		6	
Orange County		3	
Riverside-San Bernardino		8	79
Louisville	237	11	
Group: Technical		7	
Subsection: Lexington		6	
Joint Meeting: Section and Lexington Subsection		1	25
Lynn	301	19	
Subsection: Merrimack Valley		10	29
Madison	104	7	
Joint Meeting: Madison and Milwaukee Sections		1	8
Maine	130	8	
Groups: Augusta Power Technical		7	
Northern Maine Technical		1	
Portland Area Technical		6	22
Mansfield	117	9	
Group: Technical		3	12
Maryland	965	9	
Groups: Aircraft Technical		5	
Automatic Control		5	
Communications		3	
Industrial Electronics		3	
Management		4	
Power		4	
Subsection: Eastern Shore		8	41
Memphis	164	10	
Group: Transmission and Distribution		6	
Subsection: Jackson		9	25
Mexico	175	23	
Group: Technical		7	30
Miami	293	12	
Groups: Communications		1	
Grounding		2	
Subsection: Palm Beach		9	24
Michigan	1,145	6	
Groups: Communications		3	
Industry		3	
Power		6	
Professional Development		6	
Science and Electronics		3	27
Milwaukee	979	10	
Groups: Basic Sciences		4	
Electrical Machinery		3	
Electronics Discussion		3	
Power Application and Control		4	
Transmission and Distribution		5	
Subsection: Racine–Kenosha		7	36
Minnesota	510	16	
Subsection: Red River Valley		9	25
Mississippi	96	7	
Groups: Communications		9	
Power Discussion		7	23

Section	AIEE Members August 1959	Number of Meetings	Total Number of Meetings
Montana	124	4	
Group: Technical		2	
Subsections: Billings		11	
Butte		2	
Helena		10	29
Montreal	599	13	
Subsection: Quebec		7	20
Nashville	120	6	6
Nebraska	249	10	
Groups: Applications and Industry		4	
Communications		3	
Power Apparatus and Systems		3	
Technical		7	27
New Hampshire	173	6	
Group: Technical		6	12
New Orleans	291	11	
Groups: Communications		1	
Industrial		1	
Science and Electronics		4	17
New York	6,030		
Groups: Basic Sciences		1	
Communications		10	
Illumination		4	
Land		3	
Power and Industrial		19	
Transportation		9	
Subsections: Hudson Valley Division		7	
New Jersey Division		7	60
Niagara Frontier	408	9	
Group: Technical		12	21
Niagara International	147	11	11
North Carolina	573	2	
Groups: Substation, Transmission and Distribution of Charlotte Subsection		6	
Industrial Power and Control of Charlotte Subsection		6	
Subsections: Charlotte		8	
Eastern North Carolina		9	
Mid-State		10	
Western North Carolina		8	49
North Texas	741	10	
Groups: Aircraft		1	
Communications		1	
Industrial		5	
Power Generation and Rotating Machinery		5	
Protection		1	
Relay and Protective Devices		2	
Relaying Discussion		2	
Substation, Distribution, Switchgear and Transformers		4	
Substations and Switchgear		1	
System Engineering		4	
Subsections: Central Texas		9	
Fort Worth		7	
West Central Texas		9	61
Northeastern Michigan	136	13	13
Northeastern Wisconsin	114	10	
Group: Technical		1	11
Northern New Mexico	215	5	
Subsection: Los Alamos – Santa Fe		10	15
Oak Ridge	66	11	11
Ohio Valley	75	10	
Subsection: Scioto Valley		3	
Joint Meetings: Scioto Valley and Chillicothe Subsections		4	17
Oklahoma City	217	7	
Groups: Communications		5	
Discussion		4	
Industrial Practices		4	
Management		1	
Power Systems		9	30
Ottawa	120	16	16
Panhandle Plains	157	8	
Group: Technical		9	17
Philadelphia	2,180	16	
Groups: Aircraft Electrical Discussion		5	
Communications		4	
Computer		5	
Electronics Discussion		3	
Industrial Practices Discussion		4	
Management		4	
Measurements and Control		1	
Power Systems		5	
Science, Electronics and Instrumentation		7	
Subsection: Atlantic City Division		7	
Joint Meetings: Basic Science and Science, Electronics, Instrumentation		1	
Communications and Measurements-Control		1	63
Pittsburgh	1,634	29	
Group: Technical Discussion		2	
Subsections: Centre County		9	
Upper Monongahela		3	43
Pittsfield	430	13	
Groups: Power		1	
Science and Electronics		4	
Subsection: Vermont		8	26
Portland	525	21	
Groups: General Applications and Safety		1	
Industrial		1	
Power		5	
Technical		23	
Subsections: Eugene		5	
Medford		8	64
Providence	259	11	
Groups: Cable		2	
Electronic		6	
Power		4	23
Richland	119	13	
Groups: Industrial Power Systems		1	
Nucleonics		1	
Transmission and Distribution		1	
Subsection: Walla Walla		4	20
Ridgway	65	9	9
Rochester	324	19	
Group: Technical		1	20
Rock River Valley	155	10	10
Sacramento	189	7	
Groups: Electronic		4	
Transmission and Distribution		8	
Subsection: San Joaquin		4	23
St. Louis	812	11	
Groups: Education		1	
Industrial Apparatus		8	
Power Practices		9	
Technical		3	
Subsection: Eastern Division		6	38
St. Maurice Valley	57	9	9
San Diego	321	10	
Groups: Aircraft and Missile		5	
Electronics		6	
Management Development		6	
Utility		6	53
San Francisco	1,873	11	
Groups: Communications		7	
General Applications		6	
Industry		4	
Instrumentation		4	
Power		5	
Science and Electronics		8	
Subsections: Fresno		8	
Reno		9	
San Jose		1	
Santa Clara		7	
Shasta		8	
Joint Meetings: Industry and Power		2	
Science and Electronics Group and Santa Clara Subsection		1	81
Savannah	53	4	4
Schenectady	854	14	
Group: Technical		4	
Subsection: Adirondack		5	23
Seattle	877	6	
Groups: Aircraft		8	
Basic Sciences		4	
Feedback Control		5	
Industrial		2	
Management		1	
Power Technical		3	
Subsections: Alaska		4	
Tacoma		8	
Joint Meetings: Section and Power		1	
Section and Management		2	44
Sharon	248	16	
Group: Technical		2	18
Shreveport	174	9	
Groups: Relay and Control		1	
Transmission and Distribution		5	
Subsection: Monroe		7	
Joint Meetings: Relay and Control and Petroleum		1	
Section and Monroe		2	25
South Bend	125	14	
Groups: Domestic and Commercial Applications		1	
St. Joseph Technical		4	19
South Carolina	241	2	
Subsections: Central Savannah River		7	
Charleston		10	
Columbia		10	
Piedmont		10	59
South Texas	134	12	12
Spokane	215	12	
Groups: Electronics		4	
Industrial Applications		3	
Management		3	
Nuclear Power		1	
Transmission and Distribution		6	
Subsection: Wenatchee		8	37
Springfield	136	11	
Group: Technical		2	13
Susquehanna	150	8	8
Syracuse	501	6	
Group: Power		5	
Subsection: St. Lawrence International		6	
Joint Meeting: Section and St. Lawrence International		1	18
Toledo	183	21	21
Toronto	756	15	
Communications		5	
Discussion		9	
Joint Meetings: Section and Discussion		1	
Section, Hamilton Section, London and Guelph Subsections		1	31
Tulsa	226	11	
Group: Technical		15	26
Utah	147	9	9
Vancouver	307	8	
Groups: Discussion		10	
Electronics		5	
Industrial Power		1	
Power Study		12	36
Victoria	90	10	
Groups: Generating and Substations		4	
Industrial		3	
Relay		3	
Transmission and Distribution		2	
Transmission Line Performance		4	26
Virginia	359		
Subsections: Blue Ridge		7	
Hampton Roads		9	
Richmond		8	24
Virginia Mountain	252	9	9
Washington	1,075	12	
Group: Management		2	14
West Michigan	125	9	
Group: Technical		2	11
West Virginia	133	9	9
Wichita	164	8	
Group: Technical		7	15
Worcester	128	7	
Groups: Insulated Conductors		1	
Transmission and Distribution		3	11
	50,363		2,709

Total Sections, 112
Total Technical Groups, 224
Total Subsections, 77

Table II. Branch Meetings Held During Year Ending April 30, 1959

Branches	Number of Meetings
Air Force Institute of Technology	7
*Akron, University of	7
Alabama Polytechnic Institute	14
*Alabama, University of	14
Alaska, University of	11
*Alberta, University of	7
†Arizona State College	7
*Arizona, University of	10
*Arkansas, University of	10
†Bradford Durfee College of Technology	3
†Bradley University	2
†Brigham Young University	8
*British Columbia, University of	21
*Brooklyn, Polytechnic Institute of (Day)	21
*Brooklyn, Polytechnic Institute of (Eve)	4
*Brown University	0
*Bucknell University	7
†Buffalo, University of	8
*California Institute of Technology	3
†California State Polytechnic College	6
*California, University of	13
*Carnegie Institute of Technology	7
*Case Institute of Technology	4
*Catholic University of America	5
†Christian Brothers College	6
*Cincinnati, University of	11
*Clarkson College of Technology	4
*Clemson A & M College	11
*Colorado State University	11
*Colorado, University of	8
*Columbia University	4
*Connecticut, University of	9
*Cooper Union	5
*Cornell University	3
*Dayton, University of	22
*Delaware, University of	5
*Denver, University of	22
*Detroit, University of	14
*Drexel Institute of Technology	2
Duke University	6
Fenn College	14
*Florida, University of	12
†Gannon College	9
*George Washington University	7
Georgia Institute of Technology	14
†Houston, University of	14
*Howard University	13
Idaho, University of	12
Illinois Institute of Technology	18
*Illinois, University of Chicago Division	4
*Iowa State College	8
Iowa, University of	30
*Johns Hopkins University	15
Kansas State College	5
*Kansas, University of	6
Kentucky, University of	8
*Lafayette College	9
Lamar State College of Technology	7
Laval University	5
*Lehigh University	7
*Louisiana Polytechnic Institute	15
*Louisiana State University	12
*Louisville, University of	13
*Maine, University of	8
*Manhattan College	11
*Marquette University	7
*Maryland, University of	6
*Massachusetts Institute of Technology	1
*Massachusetts, University of	6
†Merrimack College	2
†Miami, University of	7
*Michigan College of Mining & Technology	7
*Michigan State University	7
*Michigan, University of	13
Milwaukee School of Engineering	9
*Minnesota, University of	19
Mississippi State College	10
*Missouri School of Mines & Metallurgy	11
*Missouri, University of	11
*Montana State College	8
*Nebraska, University of	10
*Nevada, University of	7
Newark College of Engineering	6
†New Bedford Institute of Technology	7
*New Hampshire, University of	8
*New Mexico State University	10
*New Mexico, University of	5
*New York, College of the City of	13
*New York University (Day)	11
*New York University (Evening)	8
*North Carolina State University	11
*North Dakota State College	10
*North Dakota, University of	5
*Northeastern University	23
*Northwestern University	22
*Norwich University	10
*Notre Dame, University of	8
*Ohio Northern University	8
*Ohio State University	11
*Ohio University	7
*Oklahoma State University	8
*Oklahoma, University of	7
Oregon State College	8
*Pennsylvania State University	7
*Pennsylvania, University of	10
Pittsburgh, University of	26
*Pratt Institute	3
*Princeton University	7
Puerto Rico, University of	2
*Purdue University	17
*Rensselaer Polytechnic Institute	8
*Rhode Island, University of	7
*Rice Institute	6
*Rose Polytechnic Institute	5
*Rutgers University	16
Saint Louis University	0
†San Jose State College	0
*Santa Clara, University of	8
†Seattle University	6
*South Carolina, University of	7
South Dakota School of Mines & Technology	6
*South Dakota State College	15
*Southern California, University of	6
*Southern Methodist University	8
Southwestern Louisiana Institute	7
*Stanford University	9
*Stevens Institute of Technology	13
*Swarthmore College	6
*Syracuse University	6
†Tennessee Polytechnic Institute	13
Tennessee, University of	8
*Texas, A & M College of	12
†Texas College of Arts & Industries	8
*Texas Technological College	8
*Texas, University of	6
Texas Western College	7
*Toledo, University of	12
*Toronto, University of	6
*Tufts College	8
*Tulane University	7
*Union College	2
United States Naval Academy	5
United States Naval Post Graduate School	2
Utah State University	12
*Utah, University of	28
Valparaiso University	0
Vanderbilt University	11
*Vermont, University of	3
*Villanova University	15
Virginia Military Institute	13
*Virginia Polytechnic Institute	12
*Virginia, University of	11
*Washington, State College of	10
*Washington, University of	26
*Washington University	6
*Wayne University	11
†West Virginia Institute of Technology	8
*West Virginia University	7
†Wichita, University of	2
*Wisconsin, University of	7
*Worcester Polytechnic Institute	7
*Wyoming, University of	13
*Yale University	3
*Youngstown College	15

Total Branches, 164
*Joint AIEE–IRE Branches, 116
†Affiliate Branches, 17

(*Continued from page 1228*)

World War II, surviving the German occupation. He returned to the United States in 1949, from Denmark, and retired in 1950. Mr. Brofos was decorated by the King of Norway with the Knight's Cross, 1st Class, of the Order of St. Olav, and by the King of the Belgians with the Knight's Cross, 1st Class, of the Order of Leopold.

Henry Chamberlain Clement (AM '07, M '13, Member for Life), an electrical engineer with the General Electric Company (GE) for 40 years until his retirement in 1948, died recently at his home in Rutherford, N. J., at the age of 77. He joined GE in October 1904, following graduation from the University of Vermont with a B.S. degree in electrical engineering. He returned to the university in 1905 to become an instructor in electrical engineering and to take postgraduate work in electrical engineering. He did interurban railway and central station engineering for J. C. White, New York, N. Y., and after this became valuation engineer with the New York State Public Service Commission. He returned to GE in 1910, as salesman, Lighting Sales Division, New York District. In June 1919, he was assigned to integration of companies in the syndicate department, and, in 1923, he was representative in the Sales Division of the central station department. He became assistant to the manager of the New York District in 1942.

Paul MacGahan (AM '02, M '15, F '42, Member for Life), an electrical engineer with Westinghouse Electric Corporation for 48 years until his retirement in 1945, died recently at his home in Orange, N. J. He held more than 80 patents on electrical devices he designed privately and for Westinghouse. One of his inventions was a motor for electric clocks. Born August 13, 1874, in Biarritz, France, he received the electrical engineering degree in 1896 from the School of Mines at Columbia University. In 1896-98, he took the shop course at Westinghouse Electric and Manufacturing Company. During his career, he specialized in the development of measuring instruments. He was a member of Sigma Xi fraternity. He served on the following AIEE Committees: Protective Devices (1918-20); Instruments and Measurements (1922-45); and Technical Program (1931-33).

Robert C. Schwantes (AM '51), research engineer for the Univac Division of Remington Rand, Inc., St. Paul, Minn., died recently at the age of 32. He was born December 22, 1926, in St. Paul. In 1949, he received the bachelor's degree in electrical engineering from the University of Minnesota, and later took his master's and doctor's degrees in electrical engineering from the university. Dr. Schwantes was employed in 1949 as a research associate for the Lighting and Transients Research Institute Minneapolis, Minn. He was a member of Eta Kappa Nu, electrical engineering honor society.

OF CURRENT INTEREST

TRAINING of military personnel in the complex technology of the nuclear and space age will be speeded up by the use of the "Tutor," an automated teaching machine, developed by Western Design Division of U. S. Industries, Inc. Multiple-choice solutions to problems are seen on the viewing screen where images are controlled by pushing the numbered buttons on the selector keyboard. The answer chosen and the time elapsed from the previous answers are recorded by the printing mechanism at the top of the cabinet.

Automated "Tutor" Ensures Active Student Participation

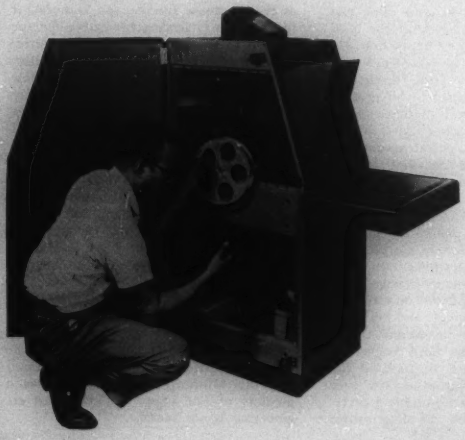
A "TEACHING MACHINE," specifically designed to meet the needs of complex modern industrial and military training programs, was introduced recently by Western Design, a division of U. S. Industries, Inc.

Called the "Tutor," the new automated device ensures active participation by the student, while simultaneously grading his work and timing his performance. It is part of a completely new tutoring method which is intended to augment teaching and training procedures in use at the present time.

While incorporating basic characteristics of all mechanical teachers—presenting information to be learned in words and pictures and testing the trainee—the Tutor has two features which represent a major breakthrough in the development of teaching machines.

By treating the trainee as an intelligent human being, the Tutor advances him at a rate determined by his demonstrated ability to absorb the information presented.

In addition, it records the progress of the trainee and provides a record of the individual's approach and reasoning process.



INTERIOR of the "Tutor"—automated teaching machine. A technician installs a reel containing 10,000 frames of visual material used in the instructorless teaching system developed by Western Design.

Provides Interaction

C. W. Sponsel, president of Western Design, said the automated Tutor for the first time makes possible interaction between a teaching machine and the trainee.

"No teaching machine has ever before been able to do the complete teaching function by achieving such thorough student participation, although this has been the ultimate aim of all of them," Mr. Sponsel said.

He added that the tutoring method perfected by Western Design and used in its new teaching device will be adapted to book format. In this connection, a contract has been negotiated with Doubleday & Co., Inc., under which Doubleday will begin publication in 1960 of a series of books utilizing this system of teaching.

The Doubleday books will be of a scrambled nature—their pages will not be arranged in any consecutive order. The sequence will be so arranged as to ensure that the student has full grasp of one concept before he proceeds to the next. The texts will cover a wide variety of technical and general interest subjects.

Automated Device

The Tutor is partly a picture projector, which also will present moving sequences, and partly an automation system. In simplest terms, it can be described as an automated "reader" that locates and presents any selected image or images when a number is punched on its keyboard.

The student begins by pushing the number 1 on the keyboard, and the image number 1 appears on the viewing screen. The image contains the first unit of information on the given subject, plus a multiple-choice question based on that information, with each alternative answer showing a new image number before it. The student selects his answer and enters its number on the keyboard, whereupon the Tutor locates and presents the new image. If the answer was incorrect, the

image tells the student so, explains why, supplies him with additional material to correct his error, and instructs him to return to the first image and try again

If the student selects the right answer, however, the device congratulates him, supplies him with the next unit of information and the next multiple-choice question.

Thus, the machine develops knowledge of the subject matter step-by-step, at any student's own pace, making sure at each step that the point has been grasped completely.

The machine includes a film bank accommodating up to 10,000 frames, automatic sequence and projection apparatus, selector buttons, viewing screen, and a tape printing mechanism which records the student's progress. In addition, it contains a search control mechanism partly electromechanical, in which electronic elements contain no vacuum tubes but only solid-state devices for highest reliability.

The functional specifications of the Tutor are as follows:

1. *Film Used:* All material, microfilmed or motion-picture, is handled on 35-mm motion-picture film.

2. *Film Capacity:* The device holds up to 10,000 microfilmed or motion-picture images, any one of which may be selected by number from the selector keyboard.

3. *The Image;* The image is presented on a rear projection screen with an area of 8.2 inches horizontal by 11.2 inches vertical.

4. *Search Speed:* The machine covers 24 images per second while moving to the image selected.

5. *Search Method:* The search control unit is bi-directional, and searches either forward or backward from any given position without resetting.

6. *Recording Mechanism:* The sequence of images viewed by the student, and the time spent viewing each, are recorded numerically on a paper tape. Time is recorded cumulatively.

7. *Reliability:* The film-handling mechanism is a specially designed, professional quality, 35-mm picture projector including a highly reliable search control device. The only maintenance is routine cleaning and oiling of the moving parts every 200 hours of use.

Reduces Training Time

"The new teaching device," said Mr. Sponsel, "reduces time in training, and gives a better level of education with at least a 20 per cent saving in training time. It is a simple matter to revise microfilm in the machine to keep up with technological changes in subject mattter presented. The machine provides complete control of subject matter and assures efficiency of training, since it will show immediately if any one subject is not being covered properly."

Western Design plans to have a complete line of Tutors ranging in price from $200 to $12,000. There will be standard materials available for the machines and special courses will also be prepared. The machines will also be offered on a lease basis.

Air-Conditioned Suit Being Developed for Navy

The fighting man of the future some day may be individually air-conditioned. Placed inside a protective garment, a miniature air conditioner would create an artificial environment, keeping him dry and comfortable at temperatures from the below-zero cold of the far North to the searing heat of the tropics.

Under a contract with the U.S. Navy, Westinghouse scientists and engineers already are at work on the advanced air-conditioning "package" needed to bring the suit to reality.

Dr. R. A. Ramey, manager of the Westinghouse new products engineering department, said that the air conditioner is being developed for the Clothing and Textile Division of the U.S. Naval Supply Research and Development Facility, Bayonne, N.J., where it will be built into an experimental "lightweight, impermeable, insulated, personnel protective garment."

Dr. Ramey reported that the air conditioner will use thermoelectric cooling which is accomplished simply by passing an electric current through small elements of a solid semiconductor material. By reversing the current, the thermoelectric materials will heat instead of cool. Thus, the air inside the suit can be heated, cooled, and maintained at any desired temperature automatically.

The complete air conditioner, Dr. Ramey said, will consist of three main components: a thermoelectric cooling and heating unit, a lightweight battery power supply, and a blower system to circulate the air inside the suit. The air conditioner will be designed to maintain the temperature in the suit at comfortable levels, roughly equal to that normally encountered on a warm pleasant summer day, while the suit is being worn in temperatures ranging from 40 below zero to 135 F.

"Although electrically heated units have had rather widespread military use, this marks the first time that an attempt has been made to completely air-condition an individual garment," Dr. Ramey pointed out. "Until the advent of thermoelectric refrigeration, there has been no light, compact, portable means for air cooling on the scale required. This air-conditioned suit is an excellent example of the important new applications made possible by this revolutionary new refrigeration technique that requires no moving parts and can be built to cool a cubic inch of space just as efficiently as it does a full-scale refrigerator."

The conditioned air circulating inside the Navy suit will not be used for breathing purposes. A separate external system, provided by the Government, will supply air for respiration. The most efficient, lightweight, rechargeable batteries will power the air conditioner and will supply enough electric energy to operate the suit for a minimum of one hour. In addition, the suit will be designed so that it can be plugged into an external power source, Dr. Ramey reported.

Future Meetings of Other Societies

Society of Plastics Engineers

Regional Technical Conference on Stability of Plastics, joint National Academy of Sciences (NAS), Dec 1, NAS Auditorium, Washington, D. C. Myron DeFries, Atlantic Research Corp, Alexandria, Va.

16th Annual Technical Conference, Jan 12-15, 1960, Conrad Hilton Hotel, Chicago, Ill. SPE, 65 Prospect St., Stamford, Conn.

Institute of Radio Engineers

4th Midwest Symposium on Circuit Theory, Dec. 1-2, Brooks Memorial Union, Marquette Univ, Milwaukee, Wis. W. B. Berry, Coll of Engg, Marquette Univ, 1515 W Wisconsin Ave, Milwaukee, Wis.

Professional Group of Vehicular Communication, Annual Meeting, Dec 3-4, Colonial Inn & Desert Ranch, St. Petersburg, Fla. J. H. Mitchell, WFLA Radio & TV, 905 Jackson St, Tampa, Fla

National Warm Air Heating and Air Conditioning Association, Annual Convention, Dec 1-4, Chase Hotel, St. Louis, Mo. Association Hdqtrs, 640 Engineers Bldg, Cleveland 14, Ohio.

ASME, Annual Meeting, Dec 1-4, Chalfonte-Haddon Hall, Atlantic City, N. J. L. S. Dennegar, 29 W 39 St, New York 18, N. Y.

27th Exposition of Chemical Industries, Dec 1-4, New York Coliseum, New York, N. Y. E. K. Stevens, International Exposition Co, 480 Lexington Ave, New York 17, N. Y.

The Metallurgical Society of AIME, 17th Annual Electric Furnace Conference, Dec 2-4, Cleveland Hotel, Cleveland, Ohio. Electric Furnace Committee, Iron and Steel Div, Metallurgical Society of AIME, 29 W 39 St, New York 18, N. Y.

AIChE, 52nd Annual Meeting, Dec 6-9, Sheraton Palace Hotel, San Francisco, Calif. Prof. T. Vermullen, Dept of Chem Engg, U of Calif, Berkeley, Calif.

IAS. Wright Brothers Lecture, Dec 17, Smithsonian Institution Natural History Bldg Auditorium, Washington, D. C. IAS, 2 E 64 St, New York 21, N. Y.

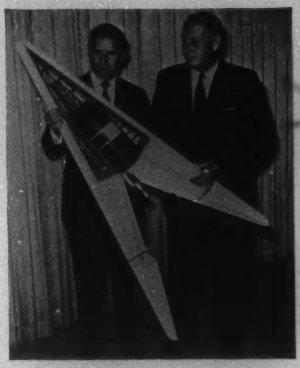
AAAS, 126th Meeting, Dec 26-31, Hotel Morrison, Chicago, Ill. AAAS, c/o Engineers Joint Council, 29 W 39 St, New York 18, N. Y.

Overseas

IEE, Discussion Meetings on Reliability and Maintenance of Digital Computer Systems, Jan. 20-21, 1960. IEE, Savoy Place, London, WC 2, England. IEE same.

Conference on Automatic Computing and Data Processing in Australia, May 24-27, Univ of Sydney and Univ of New South Wales, Australia. *Deadline for paper summaries:* Feb 1, 1960. C.H.D. Harper, Australian Natl Committee on Computation and Automatic Control, The Institution of Engineers, Science House, 157 Gloucester St, Sydney, Australia.

3rd International Electronic Parts Show, Feb 19-23, 1960, Parc des Expositions de la Porte de Versailles, Paris, France. National Federation of French Electronic Industries (FNIE), 23 Rue de Lübeck, Paris 16, France.



MODEL of proposed "space ferry" (*right*), designed to shuttle men and materials between earth and outer space to rendezvous with satellites or to construct and maintain space stations, is inspected by Hughes vice-president R. E. Wendahl and Lockheed vice-president B. C. Monesmith. *Left:* Diagram of typical mission. Arrows (*reading clockwise*) show the man-carrying vehicle being fired (1), mounted atop a powerful 3-stage rocket; after first-stage rocket separates, second-stage charge blasts arrowhead-shaped space ship still higher (2), and third-stage completes the climb to orbit altitude, 300 to 500 miles above the earth; there, (3) the symmetrically-shaped vehicle unfolds to form a 1,000-square-foot flying wing. The cylindrical core of the unit carries a pilot and as many as three passengers, along with large quantities of materials; typical payload would total 14,000 pounds. The pilot guides the ferry to its destination in space—perhaps repair of a satellite (4)—by use of reaction jets spaced along the wing's edges and by internally housed, electrically driven inertia wheels. For return to earth, the ferry also is maneuvered and controlled by the pilot, who can make a gliding landing at speeds below those of existing airliners. The vehicle is reusable and can repeat the entire operation on schedule.

Earth-to-Space "Ferry" Designed To Carry Astronauts

PLANS for a "commuter express" designed to shuttle men and materials between earth and outer space for construction and maintenance of orbiting space stations have been announced by Lockheed and Hughes Aircraft Companies.

Combining features of a space ship, a ballistic missile, and a conventional airplane, it could be ready for service by the mid-1960s, the companies reported.

It could carry up to four astronauts—a pilot and three commuters ready to step into their "workshop in space"—and large quantities of materials. Designed for flexibility, its payload would vary from mission to mission.

Taking off from earth, it would orbit at 300 to 500 miles altitude, rendezvous with other spacecraft, transfer technicians and supplies, return safely to earth, and repeat the entire operation on a routine schedule.

Called a "space ferry," the system could undertake a variety of missions, including tracking and inspection of unidentified objects in space; serve as a "space sweeper" to remove derelicts from spacelanes; act as a space systems laboratory testing and training facility; and perform short-term scientific missions on an "excursion" basis.

Typical Mission

A typical rendezvous mission with a space station could be accomplished in two to ten orbits covering 3 to 12 hours. In a typical mission, the space ferry could be expected to carry 14,000 pounds of payload.

At the time of launch, the proposed vehicle, described as a "folding arrow wing configuration," would encase a cylindrical container housing pilot, passengers, and payload. It would be mounted atop a 3-stage super-powered rocket with a gross weight of approximately 1 million pounds. The rocket would be programmed for automatic guidance through the three basic propulsion stages.

Timed to arrive in space near its target station, the space ferry would change from its symmetrical arrowhead arrangement to a flying wing configuration, unfolding a 1,000-square-foot wing and exposing the payload cylinder.

The pilot then would take control of the craft using special optical and/or radar homing devices to gain information on the direction and distance to the station. He would control the vehicle by reaction jets spaced along the wing edges and by internally housed, electrically driven inertia wheels.

Upon obtaining visual contact with the space station—at about 500 feet—the pilot would maneuver into position, fasten the ferry onto the station, and the passengers, attired in special space suits, would enter the space station through an airlock or simply step from the ferry to an external platform.

Return to Earth

Return through space and entry into the earth's atmosphere is regarded by the project engineers as the most difficult problem of the entire mission.

The proposed configuration is a "lifting re-entry" vehicle which provides maneuverability and control of the ferry during the re-entry phase. Lockheed engineers proposed advanced materials and structural concepts to overcome extreme temperatures—ranging up to 2,500 F—expected on re-entry into the earth's atmosphere. A unique Hughes-designed automatic control system will control extreme temperatures during descent and smooth out the flight path to a relatively gentle glide approach.

Landing would be accomplished in a conventional manner at a predestined point on earth at speeds below those of existing airliners.

Despite current emphasis on automatic control in space systems design, Lockheed and Hughes reported that their design approach for the space ferry involves maximum use of the human pilot "as an active element" in the control of the vehicle.

It was stated that this approach leads to a less complicated and more reliable design. Although fully automatic modes are provided for more critcal phases of the mission, the pilot can take control of the vehicle through a manual override in case of emergency, thereby giving greater assurance of safe return of the craft.

Feasible in 1965

It was also reported that the studies, financed entirely by the two companies, indicated that the ferry system would be

practical and feasible around 1965-66. Advancements in the ferry system include:

1. Development of aerodynamic and structural configurations capable of meeting a very wide range of operating conditions.
2. Development of electronic control systems permitting ferry to achieve pinpoint accuracy in rendezvous with orbiting systems.
3. Control of extreme temperatures during re-entry.
4. Reusability of the system.

Lockheed's California Division is serving as technical systems manager of the space ferry project, developing the vehicle's configuration, solving aerodynamic, thermodynamic, performance, structural, and propulsion problems; and studying life support requirements.

Hughes Aircraft Company is taking responsibility for automatic control and stabilization, guidance, navigation, communication, and instrumentation.

Electric "Bridge-Building Machine" To Help Span Lake Maracaibo, Venezuela

FOUR nations will combine talents to construct a 6-mile concrete bridge across oil-rich Lake Maracaibo in Venezuela, but the key tool will be a gigantic new "lake walking" machine developed by R. G. LeTourneau, Inc., of Longview, Texas.

Essentially, the "Electric Bridge Builder" is a 2,000-ton portable 3-legged island, with one of the world's most powerful marine cranes towering above its deck. It is literally going to lead the bridge, step-by-step, across the 6 miles of brackish water.

As soon as one section of the bridge is completed, the platform lowers itself to the waves, raises its three giant feet from the gumbo lake-bottom 70 feet below, then moves a short distance forward where it raises itself above the water again.

Previously, the only facility for this type of work was the use of floating barges. Desired stability was seldom more than a wish, and work schedules were at the mercy of weather conditions.

Because the new platform and crane will be raised well above any wave action, and because the platform will be supported from the lake-bottom by its three steel legs, no problem of stability is anticipated.

250-Ton Crane

The giant crane mounted on the deck is as much a phenomenon as the platform itself—not only in its massive size and lifting capacity, but also in the fact that it was built and installed and tested in less than 75 days.

Technically, the crane has a lifting capacity of 250 tons, with the 210-foot boom extended out 65 feet from its base. It will handle prestressed concrete beams weighing close to a half-million pounds.

To accomplish its task, the crane is powered by seven LeTourneau a-c and d-c electric motors, which in turn get power from dynamos driven by a battery of Cummins diesel engines totaling about 1,200 hp. More than 8,500 feet of 1½-inch steel cable, weighing no less than 15 tons, is used in lifting the loads.

Yet, despite its immense size and capacity, the crane pivots on a ball and socket (made of LeTourneau alloy steel) which is 20 inches in diameter.

In addition to lifting and placing sections for the all-masonry bridge, the new combination island and crane will be used for other strategic work.

For example, it will drill and set prestressed concrete piles which support the structure—some of which are 180 feet long and weigh 100 tons.

Another functional addition is a straw-line, or auxiliary hook, coming off the crane. This second line is designed for lighter work, but can lift 100 tons with the boom extended out to 100 ft.

One important feature, used for the first time on any platform, is an ingenious "self-leveling device." If one leg begins to settle more than the other two, this innovation automatically sounds a warning horn and can activate the nine electric motors on that leg to bring the platform up to level again.

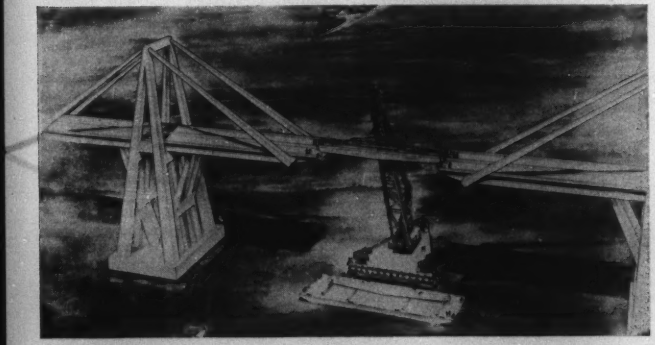
Ultimately, after the bridge project is completed, the basic platform can be put to other uses. If desired, the crane can be removed and, with a few minor modifications, the unit can become a mobile offshore drilling platform.

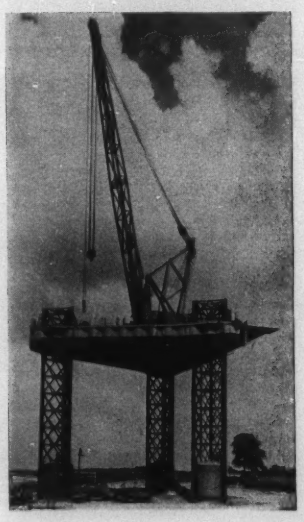
To Connect Oil Area

Purpose of the bridge is to connect the bustling oil city of Maracaibo with central and eastern Venezuela. Also, the bridge will form an important link to the Pan American Highway project. It will have ship clearance of 160 feet.

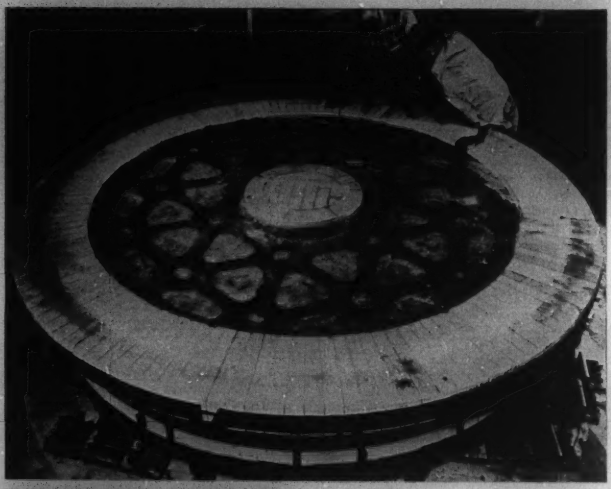
The bridge is Swiss-designed and is being built by a joint company made up of two German and Venezuelan firms—with the key Electric Bridge Builder coming from the United States.

Julius Berger, A. G., of Germany, and Precomprimido, C. A., of Venezuela, formed the joint construction company which is known as Consorcio Puente Maracaibo, Caracas.





BRIDGE BUILDING MACHINE *(right)*, **undergoing final tests before 2,000-mile tow-voyage from the United States to Venezuela. Platform will raise and lower itself in water, leading the way step-by-step to build a 6-mile concrete bridge across Lake Maracaibo. Mammoth 250-ton crane on deck has power "equal to reaching out more than 3 miles and lifting a ton." Following tests, the Electric Bridge Builder was "walked" into Mississippi where crane was dismantled and long tow-voyage began. Above: Drawing shows how the bridge builder will serve as key tool in spanning Lake Maracaibo. Both the 3-legged portable island and the super-capacity crane were built by R. G. LeTourneau, Inc.**



Corning Glass Works Photos

ABOVE: Glass telescope mirror blank, 84 inches in diameter and weighing almost 4,000 pounds, rests in the mold at Corning Glass Works where the disk was sagged from nine separate chunks of glass. Both the mold and the ceramic cores (seen through the glass) were removed before the mirror blank was readied for shipment from Corning, N. Y., to Tucson, Ariz., for grinding and polishing. Disk was made for the Kitt Peak National Observatory near Tucson. *Left:* Telescope mirror blank moves out of the annealer where the disk had been scientifically cooled for 7 months. Corning engineers inspect ceramic cores in mold. The cores (below surface of the glass) formed holes in a honeycombed pattern on one side of disk to reduce weight of the blank. The giant disk will serve as the primary reflective piece, throwing light rays from the stars toward the upper end of the telescope, where the rays fall on the eyepiece or on the photographic plate used for recording images "pulled in" from millions of light years in outer space.

Giant Telescope Mirror Blank Sent to Kitt Peak Observatory

An 84-inch telescope mirror blank has been completed by Corning Glass Works for the new Kitt Peak National Observatory under construction 40 miles southwest of Tucson, Ariz.

The disk, packaged in a special felt-lined crate, has been shipped by railroad to Tucson. There, according to Dr. A. B. Meinel, observatory director, an optical shop has been set up for grinding and polishing the 4,000-pound mirror blank. The job is expected to take 24 months.

The final precision finishing, involving removal of a few millionths of an inch of glass, will be done after the mirror has been installed in the telescope and fixed on a star. This work is expected to take another year.

The observatory, a facility of the National Science Foundation (NSF), is being operated under contract by the Association of Universities for Research in Astronomy, Inc. (AURA).

The big glass disk will join two other giant mirrors made by Corning in probing millions of light years into space. The 200-inch disk at the Hale Observatory atop Palomar Mountain in California, was cast 25 years ago. A 120-inch mirror, now in use at the Lick Observatory on Mount Hamilton in California, was cast at Corning in 1933.

The 84-inch disk is the largest of six glass mirror blanks made by Corning for the Kitt Peak Telescope. It is the biggest piece of glass ever produced by placing solid chunks of glass on a mold and sagging them into a single piece under intense heat.

Both the 200-inch and 120-inch mirror blanks were made by ladling molten glass into the molds. Corning engineers said the sagging process reduced bubble inclusions and proved less complicated and less costly.

Nine pieces of glass—one weighing 2,976 pounds—were melted down to form the 84-inch disk. The completed mirror blank is 13 inches thick and has a center hole of 26 inches in diameter.

Recently removed from an annealing oven at one of Corning's melting plants, the huge piece of glass had been sealed in the annealer for 7 months for controlled cooling after being melted to form.

The separate chunks of glass were fused under temperatures reaching approximately 2,300 F. Controlled cooling was necessary to eliminate stress in the glass.

The disk is of ribbed construction on the back face. This honeycomb pattern reduces weight while retaining necessary strength and rigidity. The pattern was formed by use of ceramic cores, bolted and cemented into the floor of the brick mold.

Each core had to be carefully separated from the glass. This was a ticklish job, handled after the mold bricks were removed and the disk was hoisted up and overturned.

Like the other big disks, the 84-inch mirror blank is made of borosilicate glass, selected because of its low expansion, thermal resistance, and mechanical strength.

The mirror must retain its shape through time, temperature changes, and mechanical stresses if astronomers are to obtain undistorted images of the stars.

The observatory atop 6,875-foot Kitt Peak will go into full operation in about 3 years. This installation and the National Radio Astronomy Observatory at Green Bank, W. Va., are the first two observatories in the United States available for the use of all qualified astronomers. Supported by the NSF with federal funds, the observatories are designed to supplement existing facilities for research in astronomy.

The Kitt Peak National Observatory will operate with a small permanent staff in co-operation with visiting scientists. Members universities in AURA include California, Chicago, Harvard, Indiana, Michigan, Ohio State, Princeton, Wisconsin, and Yale.

Smaller Mirrors in Telescope

The 84-inch disk will be one of six mirrors of borosilicate glass cast by Corning for the Kitt Peak telescope.

The giant disk will serve as the primary reflective piece, throwing light rays from the stars toward the upper end of the telescope. Here the rays fall on the eyepiece or on the photographic plate.

The secondary reflective pieces range from mirrors 29 inches in diameter down to 24 inches. They will be used to send the light to the observing instruments.

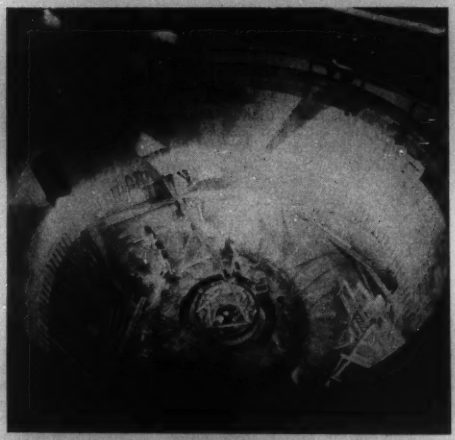
Two of the smaller mirrors will be located at the top of the telescope tubes and will be mounted in the central structure. These are hyperbolic mirrors, which magnify the image that is returned to the instruments located at the rear of the mirror cell.

The other auxiliary disks are flat mirrors located inside the tube and fork of the telescope, which will send the light down through the polar axis into the laboratory room.

Power Station Is Built Underground

Sweden's largest hydroelectric power station—the State Power Board's 375-mw Stornorrfors station on the Ume River—was officially opened recently. The station is built underground off the river bed proper. Water is conducted to the station through a 1½-mile canal, precipitated through individual penstocks to the three turbines, and reconducted to the river through a 2½-mile tailrace canal. The catchment area totals 4.4 square miles and has a length of 13⅔ miles.

The Ume River, with a mean water-flow of 16,000 cubic feet per second, ranks only fifth among Sweden's rivers, but it offers the advantage of a head of 246 feet, a figure not approached by other Swedish rivers in their lower reaches.



SWEDISH hydroelectric power station utilizes three giant Francis turbines, designed for a maximum rating of 250,000 hp, one of which is shown during process of assembly work. The turbines were built by Nydqvist & Holm AB. The Stornorrfors station, on Sweden's Ume River is built underground off the river bed proper.

Several Records Set

The building of the new power plant resulted in a number of records in size. The three Francis turbines, for example, built by Nydqvist & Holm AB and designed for a maximum rating of 147,200 kw, were at the time of construction the largest of their kind in the world (*Electrical Engineering*, May 1958, p. 474). The tailrace tunnel, with a sectional area of 4,300 square feet, is also the biggest ever driven for a hydro power project (*Electrical Engineering*, December 1958, p. 1158).

Obviously, the State Power Board technicians point out, these records were not established for their own sake but are due to a purposeful endeavor to achieve the greatest conceivable economy in operation. Every effort has been made to apply and develop the most recent advances in hydraulic engineering and to utilize the favorable natural conditions to the best advantage. As a result, it has been possible to build an installation at a cost of Kr.217,000,000, corresponding to Kr.580 ($110) per kw, a figure which also is unique of its kind.

Earth removed in the course of the construction totaled nearly 4 million cubic yards. The driving of tunnels, powerhouse, transformer hall, etc., entailed an almost equally large volume—3.6 million cubic yards. The methods developed for the tunnel-driving job included drilling from truck-mounted multistory platforms and bench-driving by means of jigs with chain-fed drills. The holes were charged by means of pneumatic charging apparatus.

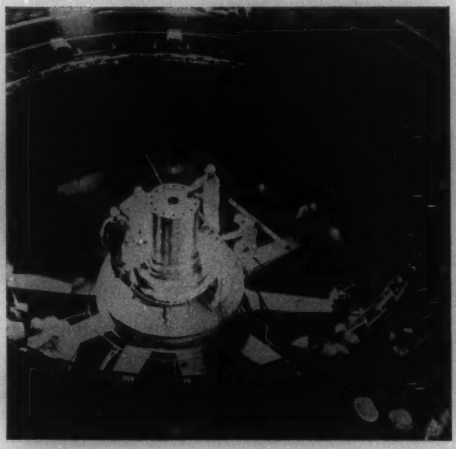
In order to provide for a timber-floating bypass at the station, an approximately 3½-mile aluminum flume has been built from the headrace canal to the outlet of the tailrace tunnel. It has a capacity of 25,000 logs per hour. The intake rests on pontoons and, thus, automatically adjusts itself to varying water levels.

The Stornorrfors station has an output of 2,200 million kwh per year and accounts for about 6.5% of the country's entire electric power production.

There are provisions for installing a fourth aggregate, which would raise the Swedish power station's rating from 375 mw to 500 mw.

TAILRACE TUNNEL, pictured in the course of construction, has a sectional area of 4,300 square feet. It represents the biggest ever driven for a hydroelectric power project. The work crew, leaving after a day's job, is dwarfed by the giant tunnel. The Swedish-developed technique for tunnel-driving, based on use of Atlas Copco equipment, facilitated the work.

Pictures courtesy of The Swedish International Press Bureau



ROTOR for one of the Swedish hydroelectric power station's three 150,000-kva Asea generators is shown being placed in position. Each unit has a weight of 974 tons. The three Asea generators were considered, at time of construction, largest of their kind in the world. Station itself is the largest built in Sweden.

Packaged Switching Circuits Prepare Data for Computer Input

The National Bureau of Standards (NBS) has developed a number of special-purpose transistorized computer packages that are expected to help automatize many of the data recording and preliminary processing tasks encountered in NBS scientific operations. These versatile building blocks, designed by a group under the direction of J. A. Cunningham of the NBS data processing systems laboratory, can be connected together systematically to accept raw data from experimental equipment and to transpose these data into a form suitable for input to a high-speed electronic computer.

Each assembly of packages can be tailored to fit the special requirements of the project, and can be used at the site of the experiment. The output from the system can be fed directly to a computer, recorded on a suitable medium for computer input at a later time, or used to drive display equipment that will keep the scientist informed of the progress of his experiment.

The accelerating pace of current scientific effort and the need for conserving technical manpower both emphasize the value of automatically recording and computing experimental data. Much human effort is spent in the simple repetitious tasks of taking data during an experiment and then performing large volumes of hand calculations. By automatizing the routine data-handling aspects of scientific experiments, savings of time and labor, as well as increased quantity and reliability of work output, can be realized both in basic exploratory research programs and in routine calibration and testing.

In surveying its own data-handling instrumentation problems, NBS decided that it could best meet its needs at this time with a series of flexible logical building blocks to record and perform preliminary processing of much of its data. These blocks can be used where (1) data are produced in large volumes; (2) data taking is extremely fast, extremely slow, or extremely precise; (3) a need exists to minimize human error, tedium, and eyestrain; or (4) computation is extensive.

THIS INSTRUMENT can test all of the various special-purpose packages under simulated operating conditions. If a package does not operate properly, the tester gives an indication of where the faulty component may be. Internal connections in the tester are made with a punched card corresponding to the type of package to be inspected.

So far, seven specialized major building blocks have been developed. A flip-flop, gating circuitry, a "one-shot" pulse generator, a logical OR-inverter, an indicator, an analog switch, and a power gate driver. They are, of course, compatible with each other and all operate at the same 50-kc pulse repetition rate.

Each package is constructed on a 4- by 5-inch plug-in printed board, and uses electronic components that are common stock items to avoid replacement problems. Most of the packages contain type *2N414* transistors, and some contain types *2N363* or *2N123* transistors. Power supply requirements are (1) −12 volts, (2) + 12 volts, (3) a reference voltage for the analog switch, and (4) any other special voltages that drive external electromechanical devices. In most of the packages, some components or subassemblies are left unconnected, and must be wired externally to the package. Connecting these components externally allows greater flexibility in combining them.

The flip-flop. The flip-flop package consists of two bistable flip-flop circuits and the necessary logical gating for converting each to one of several modes of operation. A normally open switch can be connected to the collector of either transistor to reset the flip-flop. Also in each package is sufficient circuitry to construct one bit of a double-rank shift register or two bits of a serial shift register. The output of the package can drive five other flip-flops, five OR-inverter circuits, eight gate resistors, or five gate capacitors.

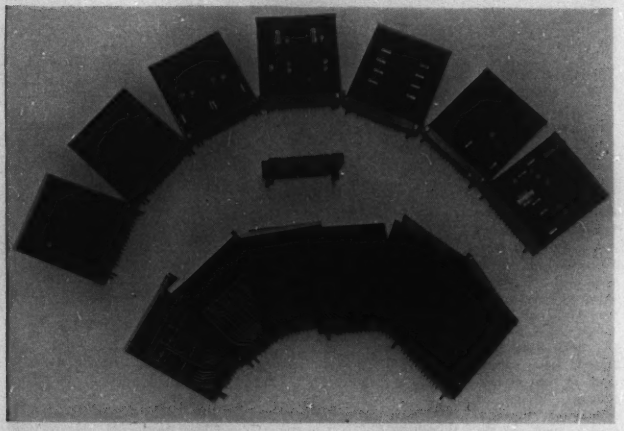
The gating package. The gating package contains eight logical gating circuits consisting of resistor-diode networks with capacitor inputs. They are mainly to supplement the gates in the flip-flop packages to complete the component requirements of shift registers, counters, or other systems. They can transfer information from a shift register or form feed-back paths in various counting configurations. These gates can be driven by the output of a flip-flop, a "one-shot" pulse generator, an OR-inverter, or a power driver.

The "one-shot" pulse generator. The pulse generator can deliver a single pulse whose duration is variable from 20 to 10,000 microseconds. Regardless of the duration of the pulse, the circuit is prepared to generate a new pulse 20 microseconds after the initiation of the first pulse.

The package consists of a flip-flop identical to the one in the flip-flop package, together with an integrator, a discriminator, and an amplifier. After the flip-flop is triggered, its output is integrated. When this integrated signal reaches a predetermined level, the discriminator is triggered. Its output is differentiated, amplified, and inverted, then differentiated again before being fed back to reset the flip-flop.

The output of the package, which can be either positive or negative, has the same driving capabilities as the flip-flop package.

The OR-inverter. Each of the OR-inverter packages, which can also be used as an AND-inverter, contains four sepa-



GROUP of seven special-purpose computer packages developed at the National Bureau of Standards to perform logical operations required for electronic data processing and recording tasks. In the upper row (*left to right*), they are: (1) an OR-inverter, (2) an indicator, (3) a flip-flop, (4) a power gate driver, (5) gating circuitry, (6) an analog switch, and (7) a "one-shot" pulse generator. Lower row shows reverse sides of a number of packages. These circuitry packages can be connected together into a system that can be used at the site of an experiment to take raw data from the equipment and process it into a form suitable for input to a computer.

rate 4-input inverter circuits. For negative input pulses, the four input diodes function as an OR-gate; for positive inputs, the diodes serve as an AND-gate. The output of the gate is amplified and inverted. One of these packages can drive six other similar packages, six flip-flops, eight gate resistors, or six gate capacitors.

The indicator. The indicator package contains circuitry for driving 10 incandescent lamps rated at 12 volts, 18 milliamperes each. This package can also drive electromechanical equipment within the power limits of its *2N363* transistors.

The analog switch. The analog switch package contains one flip-flop that controls an analog switch capable of switching up to plus or minus 10 volts within 5 millivolts of the input. By proper selection of an output resistor, the switch will present an analog voltage corresponding to a specific input quantity or digit.

The power gate driver. The power gate driver is designed to supplement the output driving capabilities of other packages. Where the output of a particular package may not have sufficient power to drive all the gates required by the system design, the gate driver—containing a number of amplifiers—can be added to drive as many as 40 other gates.

Coated Lens Panel Intercepts Radio Interference

A glass lighting panel that eliminates radio interference radiated from fluorescent lamps has been developed for laboratories, hospitals, and other areas where sensitive equipment is used.

Manufactured by Corning Glass Works, Corning, N. Y., the E-C No. 70 Low Brightness Lens Panel, specially treated to serve as a grounding shield, transmits approximately 75% of the open troffer illumination. The product has been introduced for use in research laboratories where delicate electronic equipment is affected by high-frequency radiation from the lamps, and in hospitals using electrocardiographs, electroencephalographs, hearing test equipment, and brain-wave detection apparatus. The panels also can be used in radio stores, and in schools for the deaf where radiation affects amplification apparatus.

The product consists of Corning's Pattern No. 70 Low Brightness Lens Panel coated on one side with a thin, transparent electrically conductive film. The coating intercepts the radiated interference which is grounded by a ¼-inch-wide silver strip fired onto the film around the periphery of the glass.

The company's engineers said that a lighting fixture equipped with the panel, as well as a simple line filter and CBM ballast, is virtually free of both radiated and conducted radio noise. The fixture meets military specifications (MIL-I-16910A-ships) as radio interference free.

Made of heat-resistant borosilicate glass, the panel resists heat shock and corrosion. Prismatic design has been optically engineered for accurate control of direct and reflected light. The glass face of the panel will not attract dust statically and can be cleaned with a damp cloth. The hard, electrically conductive coating is permanently fired onto the back surface of the glass and will not abrade.

The panels are thin and lightweight. A single 24- by 48-inch panel of the glass meets Underwriters' Laboratories, Inc., requirements permitting up to 1,100 square inches of exposed area.

Color Photo Enlargements Can Be Improved by Electronics

A way to make better color photographic enlargements electronically was described recently by D. R. Craig, vice-president and technical director of Log-Etronics Inc., Alexandria, Va., at the Society of Photographic Scientists and Engineers annual conference in Chicago, Ill.

Mr. Craig described application of the LogEtronic enlarger to color photo reproduction, especially to printing from color negatives. The enlarger uses an electronic scanning light source in combination with a phototube that continuously modulates its brightness.

The phototube provides automatic dodging or print correction by dimming the light source in shadow areas and increasing its brightness in highlight areas. With this method, both detail and color can be preserved in the highlights and shadows of the resulting print.

Each of the primary colors (red, green, and blue), which determine the color balance of the final print, is measured on the enlarger printing easel. Controlling the relative exposure time of each of these primary colors gives proper color balance and print density.

Fuel Cells Used To Power Experimental Tractor

An experimental fuel cell-powered tractor, recently demonstrated, develops at least 3,000 pounds of drawbar pull. enough to pull a multiple-bottom plow. The electricity that drives the tractor comes from 1,008 individual fuel cells joined in 112 units of 9 cells each. The 112 units are arranged in four banks and electricity can be taken from any combination of the banks.

A mixture of gases, largely propane, fuels the cells, which were developed at the Allis-Chalmers Research Division. The gases are fed into the cells through a system of tubing and, once in the cells, the gases react in an electrolyte. A catalyst coating the electrodes of each cell aids the reaction. The chemical reactions within the cells cause a direct current to flow through an external circuit which is connected by bus bar to a standard controller. The compact controller, measuring 8 by 11 by 21 inches, regulates the electricity supplied to a standard 20-hp d-c motor made at the company's Norwood, Ohio works.

The controller permits the tractor driver to regulate speed or reverse the tractor's direction by moving two levers. Using the speed control, the operator places the four banks of cells in series or parallel, varying the amount of current going to the motor. To reverse the tractor, the driver moves the second lever, changing the polarity of the current flow to the motor.

In field tests, the tractor pulled a 2-bottom plow through dry, hard ground. The tractor carries its gas supply in tanks mounted in brackets on the vehicle.

Engineers see in the fuel cell a valuable energy conversion method through use of off-peak generator facilities to produce hydrogen and oxygen which can be stored, transported, and utilized at will in fuel cells. Low-voltage constant loads of such electrochemical processes as plating, water purification, galvanizing, electrolytic cleaning, and electrolytic refining of metals could make use of this type of energy.

When the free energy of the reaction is converted directly into electric energy, as is the case in the fuel cell, there is no theoretical limitation on efficiency. The possibility of producing electric power directly from a fuel at an efficiency of 90%

MIXTURE of fuel gases, largely propane, and oxygen react in an electrolyte within 1,008 fuel cells to provide electricity that powers this experimental Allis-Chalmers tractor. Controller to left of driver controls tractor's speed and can reverse its direction. Fuel cell tractor develops 3,000 pounds of drawbar pull, more than enough to pull a multiple-bottom plow in field tests.

is startling when compared to the best diesel engines, which are about 40% efficient. Because the fuel cell does not involve heat but converts chemical energy directly into electric energy, it escapes the high heat engine energy losses.

Postdoctoral Awards—Applications Invited by NSF

Applications will be accepted through December 22, 1959, by the National Science Foundation (NSF) for postdoctoral fellowships to be awarded in March 1960, A. T. Waterman, NSF director, announced recently.

Fellowships will be awarded in the mathematical, physical, medical, biological, engineering, and other science fields, including anthropology, psychology (other than clinical), geography, certain interdisciplinary fields, and selected social science fields. Names of successful fellowship applicants will be announced on March 15, 1960.

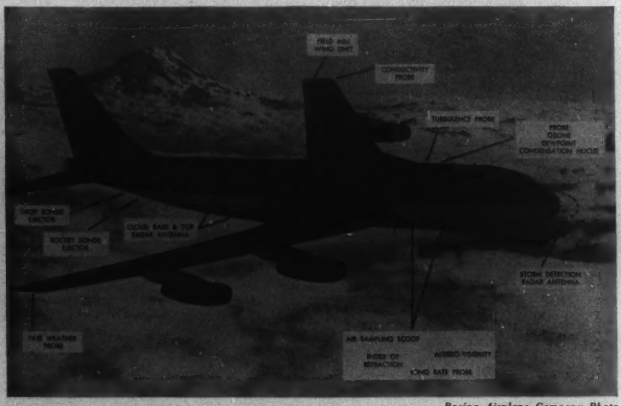
To be eligible for postdoctoral fellowships, applicants must be citizens of the United States with special aptitude for advanced training and must hold the doctoral degree or have the equivalent in training or experience.

Fellows will be selected on the basis of ability as evidenced by letters of recommendation and other evidence of scientific attainment. Applicants' qualifications will be evaluated by carefully chosen panels of scientists operating under the aegis of the National Academy of Sciences–National Research Council. Final selection of Fellows will be made by the NSF.

A stipend of $4,500 per year will be awarded to successful applicants under the postdoctoral fellowship program. Dependency allowances will be made to married Fellows. Fellows may engage in study and/or research at appropriate nonprofit American or nonprofit foreign institutions. A limited allowance to aid in defraying a Fellow's cost of travel will also be available.

Application materials may be obtained by writing to the Fellowship Office, National Academy of Sciences–National Research Council, 2101 Constitution Ave., N. W., Washington 25, D. C.

Airborne Weather Laboratory



Boeing Airplane Company Photo

A FLYING WEATHER LABORATORY, installed and test-flown in Boeing's 707 prototype jetliner, has successfully completed flight tests designed to gather and analyze global weather data for improved forecasting. Developed by an industrial team headed by Bendix Aviation Corp., the weather project, named AN/AMQ-15 Air Weather Reconnaissance System, is described as the most significant advance in meteorology since weather stations first were linked by telegraph. Dr. R. D. O'Neal, general manager of the Bendix System Division, said the tests demonstrated the feasibility of a global weather-reconnaissance system aimed at obtaining information vastly more accurate than that available today. Such a system, he said, is vital to military air power as well as everyday peace-time activity, such as airline route planning. Boeing's role in the program, as a major subcontractor to Bendix, is in developing vital sensing equipment for probing the stratospheric elements. It also provided the 707 prototype. The jet testbed, crammed with electronic sensing and computing devices, flew some 7,000 miles at altitudes up to 45,000 feet. To give the airplane a 3-dimensional reach, two kinds of launching tubes released instrumented containers—rocketsondes and dropsondes—which measure barometric pressure, temperature, ozone content, dew point, and other data from sea level to 170,000 feet altitude. The former were not "live." The flight test program was a major co-operative experiment between the Air Force, Navy, Weather Bureau, Bendix, and Boeing.

Electrical Engineering Education Conference Held at RPI and Union

A conference of some 20 professors from 14 different eastern educational institutions was held under the auspices of Rensselaer Polytechnic Institute (RPI), September 28-29, 1959.

The electrical engineering curriculum was the topic of consideration on the first day, held at RPI, with Professors W. A. Lewis, H. H. Woodson, L. V. Bewley, and P. D. Agarwal leading the discussion. While no precise agreements were reached, the statement which follows gives the consensus of the meeting.

Content of Electrical Engineering Curriculum for the Junior and Senior Years:

1. All electrical engineering students in the junior-senior years should be given a course in electromechanical energy conversion, with the purpose of giving the students an understanding of the nature, mode of operation, uses, and performance curves of usual devices, including telephone diaphragms, loud speakers, contactors, transformers, rectifiers, and synchronous, induction, and d-c machines.

2. The course should not deal with the design of any of these devices, but should provide an understanding of the basic materials, the structural arrangements, and the functioning of the various elements of each device, so that the student will have a basis for the intelligent selection, appraisal, and application of usual electrical devices.

3. Preceding this course, all students should have a basic course in electric circuits and the principles of electromagnetism.

4. Also, preceding this course the student should have adequate mathematical preparation, including complex algebra, matrices, vector analysis, and calculus, including elementary differential equations and the use of the Laplace transform.

5. The energy conversion course should include:

(A) Explanations of how to calculate the resistance, inductance, and capacitance of simple geometric forms, such as slot-embedded coils, parallel wires and plates, and uniform air gaps.

(B) Derivation of the forces between current-carrying circuits, magnetic fields, and electric charges. The force equations may be derived from Ampere's laws based on integration of the forces acting on each element of the circuit, or from differentiation of the total energy stored in the field. The force-element approach is useful for explanation, and for dealing with certain problems, but the stored energy approach is more widely useful and should be fully developed in the course.

(C) Vector analysis and matrix methods should be used throughout, and a moderate amount of space may be devoted to explanation of these procedures as they are brought in, to reinforce the prior knowledge the students should have.

(D) In general, the course should explain principles, and develop the

properties of basic kinds of circuits. Particular machines or devices that are considered should be treated as examples of the general case, with full recognition of the effects of different choices for the design parameters.

(E) Emphasis in the course should be placed on giving the student a sense of proper magnitudes, an ability to approximate, and the recognition of sound analogies, rather than giving precise formulas or any details of design or application.

6) It is desirable that there be a considerable number of different books dealing with the stated topics in different ways, and to different depths, so that each university may provide a course suited to its own teaching staff, student body, and fields of especial interest. Books that are considered especially useful at the present time are those by Adkins, Fitzgerald-Kingsley, Ku, White-Woodson, and those proposed by Bewley and by Lewis.

The question of graduate study was also considered in the light of the provocative statement by Prof. J. F. Baker, of Cambridge University, in his IME paper of July 1957, entitled "Engineering Education at Cambridge:"

> "It is, in my opinion, worse than useless to continue men on to post-graduate courses immediately following their undergraduate years."

Here again no positive conclusions were reached, but the consensus of the group is indicated by the following statement:

In the United States, there are four widely followed procedures in graduate study.

(A) The student takes up full-time graduate study immediately following his undergraduate years, often at another institution. From the student's viewpoint, this is attractive because it saves time and money. When the student has a well-defined and challenging objective, this gives good results, but it is not good if the student has no adequate or well-defined objective.

(B) The student takes up part-time teaching along with his graduate study immediately following his undergraduate years. From the institution's viewpoint, this is a very satisfactory method, because it provides teaching assistants of high quality at low cost, and because the students gain some maturity before their final choice of thesis projects, and they also have more flexibility in their programs.

(C) The student enters employment immediately following his undergraduate years, and later takes up part-time graduate study, either in the evenings or at stated periods alternating with regular work, under some co-operative plan. This method has been highly developed, in many alternative forms, and has been successful on the whole. However, it lacks the great values of out-of-class associations with university people. Also, it is not satisfactory when the student transfers from place to place, as many employers now require; or when the place of employment is far from an appropriate educational institution.

(D) The student enters employment for a few years and then takes up full-time graduate study for an extended period. This method provides graduates of the highest quality, and it is just coming into use. However, it interrupts the student's career, and it is likely to be very costly.

It was the consensus of the group that each of these methods has distinct values, and is the best for particular students. Under American conditions of early marriage and widely available assistantships, method B will no doubt continue to be the most popular. The objections to it implied in Prof. Baker's statement can be minimized by making the fullest possible use of industry and practicing engineers in the selection and conduct of thesis projects. However, the great need for more top-level engineers and scientists makes it highly desirable to extend the use of method D far more widely. Every effort should be made to encourage industrial and government support for this procedure of sending mature engineers to educational institutions for periods of full-time graduate study.

The meeting on the second day, held at Union College, was devoted to a discussion of laboratory experiments for electrical engineering students. This was led by Prof. H. W. Bibber; Prof. W. R. LePage; and S. G. Ringland of the technical department of Mt. Pleasant High School, Schenectady, N. Y.

Automatic Address Reader

A contract for the development of an advanced, more sophisticated address reader for the U. S. Post Office Department was recently awarded to the Intelligent Machines Research subsidiary of Farrington Manufacturing Co., Alexandria, Va.

An earlier model of the Farrington Automatic Address Reader, an optical scanning device that actually reads addresses faster than the human eye, has been on display at the First National Building in Detroit, Mich.

The contract calls for "advancing the development of electronic analyzing, automatic reading equipment, and for producing an engineering test model of a completely automatic letter sorting machine" as part of the Post Office's program to automate its operations completely.

The new address reader, to be a transistorized prototype of a production model, will be able to read and sort letters for 40 destinations; the earlier model was limited to 20 places. When completed, the new machine could be programmed to read a greater number of destinations than the 40 called for in the contract.

The present address reader can recognize through its character-sensing apparatus typewritten, printed, or imprinted addresses, single- or double-spaced, staggered or flush, on the facing of any size envelope. As it scans the address, the address reader sorts the envelopes into separate slots.

The newly awarded contract calls for a machine that will sort at the minimum rate of 10,000 letters per hour, more than three times the rate per person operating semiautomatic sorting machines currently being tested. Although the current experimental model and the proposed advanced device will read only printed or typed addresses, the contract calls for research into the reading of handwritten addresses.

"Handwriting Reader" Has a 10-Word Vocabulary

A small device that reads handwritten words and has a 10-word vocabulary—"zero" through "nine," spelled out—has been built. The handwriting reader, developed by Bell Telephone Laboratories, New York, N. Y., is about the size of a briefcase, and was invented to demonstrate methods which might eventually be applied in machines designed to read a wider variety of material. "Reading machines" could be valuable in any business or industry where information must now be translated into machine language by punched cards, by tape, and by pressing adding machine or typewriter keys.

In order to use the experimental handwriting reader, the writer moves a metal stylus over a special surface just as if he were writing with a pen or pencil. Then, when he touches an "Identify" button with the stylus, a light appears beside the numeral corresponding to the word he has just written.

In order to provide the writer with horizontal guide lines, two of the 15 hori-

EXPERIMENTAL machine that "reads" typewritten or imprinted addresses and sorts mail to 20 destinations was developed by a subsidiary of the Farrington Manufacturing Company.

HANDWRITING READER is demonstrated by its inventor, L. D. Harmon of Bell Telephone Laboratories. The electrically wired stylus is pressed to the "Reset" button before a word is written on the electrically connected writing surface. When the stylus is then touched to the "Identify" button, a light appears above the correct digit.

zontal bars on the writing surface, or commutator, are made of brass. These make a color contrast with the other 13, which are copper. The two brass conductors enclose the middle third of the writing space, in which the user is requested to write the small letters, such as "e" and "n." Vertically extended letters, such as "t" and "g" are carried beyond these limits.

The middle bar of the commutator is connected to a counter, which provides a rough horizontal location of features. If a recognition feature comes before the stylus has crossed the middle bar six times, the feature is considered to be in the left-hand portion of the word; if later, it is deemed to be in the center or right-hand portion.

A logic circuit examines each word scribed on the writing surface for six features. They are: a lower vertical extension, as in "g," within the left-hand portion of the word; a lower extension in the middle or right-hand portion; an upper extension, as in "t," in the left-hand portion; the presence of more than one upper-left extension; a large number (more than nine) of crossings of the middle bar (zero axis); and a dotted "i." The dotted "i" is detected as a special discontinuity when the stylus is lifted from the center portion to the upper portion of the writing surface at the end of a word. The decisions are made by a circuit of 12 relays and 8 semiconductor diodes.

The device is believed to be the first which actually reads cursive script despite variations in the individual style. It also explores machine reading by entire words rather than letter-by-letter. Machines are already in use that can read individual letters and numbers, but most require printing in a rigid type style and specific size. Among these are machines for reading the codes that appear on some credit cards. A device invented earlier at Bell Laboratories reads numbers formed around two dots (*Electrical Engineering*, April 1958, p. 396).

Current pattern-recognition research aims to eliminate or limit constraints—to find practicable, efficient ways for machines to read any reasonably legible material. The handwriting reader has one minor constraint. The user must write within limits on the special surface. L. D. Harmon, inventor of the device, explains that the stylus, which is wired, makes electrical contact with 15 horizontal metal strips alternately sandwiched between strips of electrical insulating material in the surface.

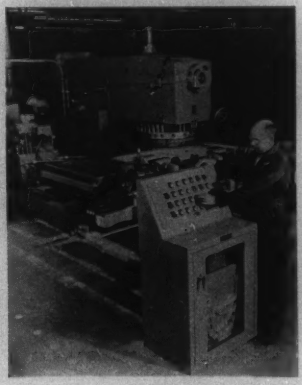
Up-and-down movements of the writing cause electric connections to be made with the metal strips in sequence. The sequence and number of connections tell the word-reading device which of the 10 words has been written. Although the device has enough flexibility to recognize most individual styles of cursive writing, it has limitations. The writer must not print the words nor lift the stylus between letters. He must dot his "i's" punctiliously in the words "five," "six," and "nine."

For a primary-grader among machines, however, the handwriting reader has a high degree of accuracy, scoring 97% in a test of 1,000 words written by 20 persons. It is felt that most of the 3% error rate can be eliminated by minor improvements.

Tape-Controlled Turret Punch Press

A new tape-controlled turret punch press, which automatically locates and pierces holes in sheet metal or plate at high speed, has been developed by the Wiedemann Machine Company using numerical positioning controls which were developed by the General Electric Company (GE).

Designed specifically for automation, the "Wiedematic" turret punch press provides an extremely fast and consistently accurate short-run piercing method. All press functions—tool selection, material positioning, and piercing—are controlled automatically. Multiple die sets, layout, tool setup, and multiple material handling are eliminated. Openings of any size or shape up to 8-inch diameter are produced in as little as one-fifth the time required with a manually operated Wiedemann turret punch press of the same size.



◀ OPERATOR stands at the console as the Wiedematic turret punch press completes an automatic sequence of locating and piercing holes in a large metal sheet at the rate of 30 hits per minute. Press operations are directed by General Electric Mark III numerical positioning controls from information programmed on standard 8-channel tape. Tape reader is shown within console cabinet. Hydraulic power unit for press is shown at the extreme left.

Operation of the Wiedematic is reduced to push-button simplicity. All of the information required to complete a job is programmed on a standard 8-channel, 1-inch-wide tape. The operator simply loads the material on the press table, inserts the tape in the reader, and starts the press. Simultaneously, the material is moved in-or-out and crosswise to the designated centerline dimension at a speed of 600 to 800 inches per minute, while the turrets rotate to bring the proper punch and die (any one of 36 mounted in the turrets) into piercing position in less than 2 seconds. As soon as all three motions are completed, the press trips. During the piercing operation, the information for the next hole is read, and the table and turrets move immediately as required with no lost time. Since all hold locations are taken from a zero reference, there is no accumulative error.

The type-*A-100* Wiedematic turret punch press in operation at the GE specialty control department in Waynesboro, Va., has a capacity of 100 tons, and a throat depth of 63 inches. It can pierce sheet metal or plate up to 60 inches by 100 inches by ¾ inch thick in a single handling at a production rate of approximately 30 hits per minute.

This press is equipped with GE modified Mark III numerical positioning control, which automatically directs all press operations. This closed-loop servo system is self-checking to assure optimum locating accuracy. All operator controls along with the tape reader are enclosed in the control console, which can be placed at any convenient location near the press.

Tape preparation is accomplished easily with either a standard tape punching machine, working to a simple work chart listing the X and Y dimensions and turret station number for each opening, or by an Auto-programmer developed by GE. This latter unit can produce a tape from a dimensionless line drawing using an optical system. With this method, drafting time can be reduced approximately 75%.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ADVANCES IN SEMICONDUCTOR SCIENCE. Edited by Harvey Brooks, Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1959. 553 pages, 7½ by 10 inches, bound. $15. This collection of papers emphasizes the fundamental aspects of semiconducting solids. Among those topics investigated are band theory, recombination and impurity centers, surfaces, dislocation, exitons and photons, optical properties, ionic crystals, magneto-optical effects, thermal conduction and thermomagnetic effects, large band gap semiconductors, and resonance. These papers constitute the Proceedings of the Third International Conference on Semiconductors held in 1958, and are published also in the January 1959 issue of the *Journal of the Physics and Mechanics of Solids*.

DIGITAL AND SAMPLED DATA CONTROL SYSTEMS. By J. T. Tou. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 631 pages, 6¼ by 9¼ inches, bound. $15. The basic theory and available techniques for the analysis and design of digital and sampled-data control systems are presented. The subject matter is divided into three parts dealing with introductory material, system analysis, and system design. It covers such advances as multirate sampling techniques, systems with nonsynchronized samplers, cyclic variable-rate sampled-data systems, adaptive control, statistical design, simulation, and systems with finite sampling duration.

THE ECONOMICS OF NUCLEAR POWER, INCLUDING ADMINISTRATION AND LAW. Volume 2. Edited by I. R. Maxwell and others. Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1959. 419 pages, 6¼ by 9¼ inches, bound. $17. A continuation of other volumes in this series (Progress in Nuclear Energy, Series VIII), the present volume discusses the world demand for nuclear energy; nuclear fuel supply and costs, with particular reference to uranium mining costs; the generation of nuclear energy, including its application to purposes other than electricity generation; the cost of generating electricity for nuclear reactors; and the effect of reactor design on costs. Nuclear power programs in various countries are also discussed.

ELECTROLYTE SOLUTIONS. By R. A. Robinson and R. H. Stokes. Second edition. Academic Press, Inc., 111 Fifth Ave., New York 1, N. Y., 1959. 559 pages, 5¾ by 9 inches, bound. $11.50. A detailed account is given of the fundamental properties of electrolyte solutions, including conductance, chemical potential, and diffusion. Modern experimental methods are discussed, and experimental results are given. In this edition, the text has been revised to include new experimental and theoretical developments, and although the book is primarily concerned with aqueous solutions, recent work on conductance in nonaqueous solutions has been added. The tables in the appendixes, particularly the tables of ionization constants of weak electrolytes, have been considerably enlarged.

ELECTROMAGNETIC RADIATION FROM CYLINDRICAL STRUCTURES. By J. R. Wait. Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1959. 200 pages, 5¾ by 8¾ inches, bound. $8. A theoretical treatment of the factors influencing the flush-mounted stub-type microwave antennas such as are used on aircraft and missiles. Following a brief review of the basic work in this field, a comprehensive discussion of slots on cylindrical surfaces is presented. These include circular cylinders, wedges, cylindrically tipped wedges, and elliptic cylinders. The application of the results to doubly curved structures such as spheres and spheroids is also presented.

Library Services

ENGINEERING Societies Library books, except bibliographies, handbooks, and other reference publications, may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint or a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 29 W. 39 St., New York 18, N. Y.

ELECTRONIC COMPONENTS HANDBOOK. Volume 3. Edited by Keith Henney and others. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 180 pages, 8¾ by 11¼ inches, bound. $10. In this final volume in the series, further information is provided which permits the designer to select and use components that perform with maximum reliability. Emphasis is placed on component types for which military specifications are available. Data is given on transformers and inductors, including power, communication, pulse, hybrid, bistable, logic, and tuned transformers, as well as magnetic amplifiers and saturable reactors; connectors, including jacks, plugs, and sockets; wire and cables; terminals; tube shields; and miscellaneous hardware.

EXPERIMENTAL NUCLEAR PHYSICS. Volume III. Edited by E. Segrè. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. 811 pages, 6 by 9¼ inches, bound. $23. This volume, which completes the series, discusses radioactive decay, alpha radioactivity, gamma rays, beta rays, and particle accelerators. Each section is intended to bring the reader up to date in experimental techniques, point out the significant facts and data, and indicate the broad lines of theoretical interpretation. In addition, the bibliographies included enable the reader to go directly to the original literature for further details.

FREQUENCY RESPONSE FOR PROCESS CONTROL. By W. I. Caldwell and others. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 395 pages, 6¼ by 9¼ inches, bound. $11.50. The fundamental methods of frequency response are presented, and their application to the analysis, testing, and design of progress control systems is discussed. The first part, which is devoted to theory, considers velocity lag, linear lag, and stability considerations. Methods of analysis are presented with emphasis on the damped-response method, while the coverage of controller responses includes control charts for a variety of responses. Closed-loop responses are explained and disturbances are discussed with regard to their magnitude and location in the control loop. The second part of the book consists of the application of these fundamentals to actual process control problems.

HEATSEALING AND HIGH-FREQUENCY WELDING OF PLASTICS. By H. P. Zade. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 1959. 211 pages, 5¾ by 8¾ inches, bound. $5.75. A summary of the present knowledge regarding these two fabricating processes is presented along with a survey of their increasing range of industrial application. Information is given on the physical properties of thermoplastics in relation to their welding properties, and there is an extensive review of heatsealing and high-frequency welding equipment, illustrated by photographs of representative types of welding machines. An index of international patents relating to the welding of plastics, and an index to trade names of thermoplastics are included.

INVENTIONS, PATENTS, AND THEIR MANAGEMENT. By A. K. Berle and L. S. de Camp. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N. J., 1959. 602 pages, 5¾ inches, bound. $12.50. While not advocating that inventors act as their own patent attorneys, this book does indicate how to proceed with an invention in its early stages; how to choose a patent attorney; how to co-operate with him to get the most from his services; and how to read, understand, and evaluate patents. In addition, the commercial exploitation of inventions is covered. It is shown that by following the correct procedure in obtaining patents, much time and expense can be saved.

MATHEMATICAL METHODS OF OPERATIONS RESEARCH. By T. L. Saaty. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 421 pages, 6¼ by 9¼ inches, bound. $10. Mathematical methods essential to operations research are presented. Following an introductory chapter on the history and basic concepts of operations research, the book continues with methods used in formulating mathematical models; optimization, programming, and game theory; probability, statistics, and queueing theory; and a discussion on creativity in relation to the solution of problems. Some knowledge of advanced calculus and matrix theory is required.

PLANT ENGINEERING HANDBOOK. Edited by William Staniar. Second edition. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. Various pagings, 6¼ by 9¼ inches, bound. $23.50. This handbook covers the various aspects of plant organization, design, construction, operation, and maintenance from the viewpoint of efficiency and economy. In this edition, new sections cover advances in standardization of engineering practice, industrial building heating, automation, synthetic lubricants, industrial electronics, as well as other areas. In addition, the sections retained from the previous edition have been extensively revised.

PROCEEDINGS OF THE FOURTH NATIONAL CONFERENCE ON TUBE TECHNIQUES. Sponsored by the Advisory Group on Electron Tubes. Published by the New York University Press, Washington Square, New York 3, N. Y., 1959. 270 pages, 8½ by 11 inches, paper. $7.50. The papers included deal with a wide variety of aspects of vacuum tube construction. Among the aspects considered are properties of getters in electron tubes, microwave vacuum tube techniques, seals for vacuum tubes, manufacturing techniques, dispenser cathodes, thermionic emitters, and interface resistance.

PROGRESS IN NUCLEAR ENERGY. (Series I, Physics and Mathematics, Volume 3.) Edited by D. J. Hughes. Pergamon Press, Inc., 122 E. 55th St., New York 22, N. Y., 1959. 403 pages, 6¼ by 9¼ inches, bound. $15. A selection of papers presented at the second United Nations Conference on the Peaceful Uses of Atomic Energy is included. Among the topics discussed are the slow neutron fission cross sections of the common fissile nuclides, radiochemical methods applied to the determination of cross sections of reactor interest, fast neutron scattering and capture by atomic nuclei, radiative capture of fast neutrons, mass distributions in thermal and resonance fission, and the use of the pile oscillator in thermal reactor problems. A number of papers are devoted to the experimental and theoretical aspects of the process of neutron thermalization and its bearing on the neutron energy spectrums in reactors.

RADIATION HYGIENE HANDBOOK. Edited by Hanson Blatz. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. Various pagings, 6¼ by 9¼ inches, bound. $27.50. The industrial, medical, and research uses of radiation and atomic energy are covered with specific reference to the field of health physics, industrial hygiene, and sanitary engineering. Essential information is provided on exposure standards, sources of radiation, waste disposal, air and water pollution control, physiological effects of radiation, along with tables and general data. Descriptions of natural and man-made sources of radiation are presented in such a way as to aid in classifying a particular hygiene problem.

THE SCIENCE OF MECHANICS IN THE MIDDLE AGES. By Marshall Claggett. The University of Wisconsin Press, 811 State St., Madison, Wis., 1959. 711 pages, 6¼ by 10 inches, bound. $8. This volume is a guide and source book for the study of the development of mechanics in the period before Galileo. It includes both extensive commentary and numerous texts, with the purpose of offering a documentary analysis of the criticism and modification of Aristotelian mechanics that took place from the 13th to the 15th Century. In the course of his study, the author establishes the importance of the medieval studies as a significant link between Aristotelian and Newtonian concepts.

SERVOMECHANISM FUNDAMENTALS. By Ben Zeines. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 257 pages, 6 by 9¼ inches, bound. $5.50. The fundamentals underlying servo systems and data-transmission systems are presented in a nonmathematical fashion. The author discusses elementary forms of control systems, servo systems, synchros, servo elements, and electronic and magnetic amplifiers. In addition, d-c and a-c servomotors are discussed in detail, and performance improvers and methods of measurement are included. A large number of diagrams, closely integrated and correlated with the textual matter, are provided.

SPACE TECHNOLOGY. Edited by H. S. Seifert. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1959. Various pagings, 6 by 9¼ inches, bound. $22.50. A thorough exposition is given of the fundamental physical principles of very-long-range ballistic vehicles, stressing the quantitative relations that are most useful for space flight. In addition to a particularly thorough discussion of ballistics and flight dynamics, coverage is given to propulsion, communications and guidance, man in space, and the scientific uses of space. The 500 selected references given provide a guide to the significant literature in this field.

STEAM POWER PLANTS. By C. D. Swift. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1959. 491 pages, 6¼ by 9¼ inches, bound. $11.50. All classes of steam boilers and steam electric plants from pressures above low-pressure heating installations up to supercritical high-temperature installations are covered. The mode of operation of the various power plant apparatus and how they are tied together into a complete operating power plant is described. Instruments, safety devices, and electric equipment are also discussed, as are the factors that must be considered in achieving economical power production.

TRANSISTOR CIRCUITS. By K. W. Cattermole. The Macmillan Company, 60 Fifth Ave., New York 11, N. Y., 1959. 442 pages, 5¾ by 8¾ inches, bound. $14. An introduction to the principal functions of transistors and to the circuit arrangements in which they can be used is presented. Beginning with the theory and manufacture of semiconductor crystals, diodes, and transistors, the author continues with a thorough treatment of single-stage, multistage, power, and high-frequency linear amplifiers. This is followed by a discussion of negative resistance, digital and pulse circuits, and frequency changing processes such as modulation and detection. Concluding sections deal with test methods and with potential applications.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

OTS PUBLICATIONS. The Office of Technical Services (OTS) has made the following reports available to the public: "Unconventional Electrical Power Sources," *PB 151726*, U. S. Air Force, Sept. 1956, 104 pages, $2.50, is concerned with the production of electrical power by conversion of five sources of energy —mechanical, thermal, chemical, solar, and nuclear; "Salvage of Flooded Electrical Equipment," *PB 151670*, U. S. Naval Research Laboratory, June 1959, 21 pages, 75¢, is an illustrated report which describes a cleaning composition that removes fuel oil from electrical equipment without harming insulation, metal, or humans, and also acts as an antirust agent; and "Advanced Propulsion Systems," *PB 151796*, Office of Naval Research, July 1958, 105 pages, $2.50, explains and evaluates propulsion motors and power sources as separate units and reviews general principles of propulsion as they apply to nonconventional systems. All three reports may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C.

INSULATION FOR SMALL TRANSFORMERS. Providing guidance and data for designers of all forms of electrical insulation, the handbook considers factors which affect the electrical strength and life of insulation in service, and provides numerous graphs. The 93-page pocket-size book was prepared by J. H. Mason and C. G. Garton, and is made available by the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Rd., Leatherhead, Surrey, England. The book compares the merits and significance of nondestructive electrical tests with the customary overvoltage tests which often give little assurance of satisfactory life in service. The electrical, thermal, and mechanical properties of wire coverings, paper, sheet, and laminate insulations are given along with problems involved in impregnation. The price is 37s/6d (about $5.25) plus postage.

ELECTRICAL CONTACTS, STP 56 M, 1958 SUPPLEMENT: BIBLIOGRAPHY AND ABSTRACTS. Covering the year 1958, this supplement brings the total number of references to over 2,500. There are 182 abstracts in the volume, as well as both author and subject indexes. The references are arranged by subject in the supplement as has been the practice in previous editions. Among the topics covered are: fabricated contact materials, powdered metals contact materials, circuit-breaker design, circuit-breaker testing, contactor or relay design, and electric arc theory. The series of which this supplement is a part consists of 7 volumes covering the period 1835 through 1958. Copies of this supplement may be obtained from American Society for Testing Materials headquarters, 1916 Race St., Philadelphia 3, Pa., at $2.50 each.

PHYSICAL AND ENGINEERING PROPERTIES OF MATERIALS FOR NUCLEAR FUEL ELEMENTS. This is a compendium of physical and engineering data about elements, alloys, compounds, and other materials of particular interest to those engaged in the design, fabrication, and use of nuclear fuel and control elements. It was compiled and includes an introduction by Dr. H. H. Hausner, adjunct professor, Polytechnic Institute of Brooklyn, and consultant to Sylvania-Corning Nuclear Corp., Bayside, N. Y. Among the 80 tables presented are thermal-neutron cross sections of 50 commonly available elements, and various physical and thermal properties of uranium, uranium alloys, thorium, plutonium, ceramics, zirconium and zircaloy-2, aluminum, stainless steel, graphite, and other high-temperature materials. The 55-page book, multilithed, is available at $1 from Sylvania-Corning Nuclear Corp., Bayside, N. Y.

AMERICAN STANDARDS. Revisions of the three basic American Standards for metal conduit and tubing for electric raceway systems have been approved and published by the American Standards Association (ASA). Of interest to contractors and other users of electric wiring as well as to manufacturers, the three standards cover zinc-coated rigid steel conduit, enameled rigid steel conduit, and zinc-coated electrical metallic tubing used as raceways for the wires or cables of an electric system. The three revised standards are: *Rigid Steel Conduit, Zinc-Coated*, C80.1-1959; *Rigid Steel Conduit, Enameled*, C80.2-1959; and *Electrical Metallic Tubing, Zinc-Coated*, C80.3-1959. All three standards give tables of dimensions and weights, coatings, and identification, as well as test and inspection procedures. They are available at 80¢ a copy from ASA, Dept. PR 104, 70 E. 45th St., New York 17, N. Y.

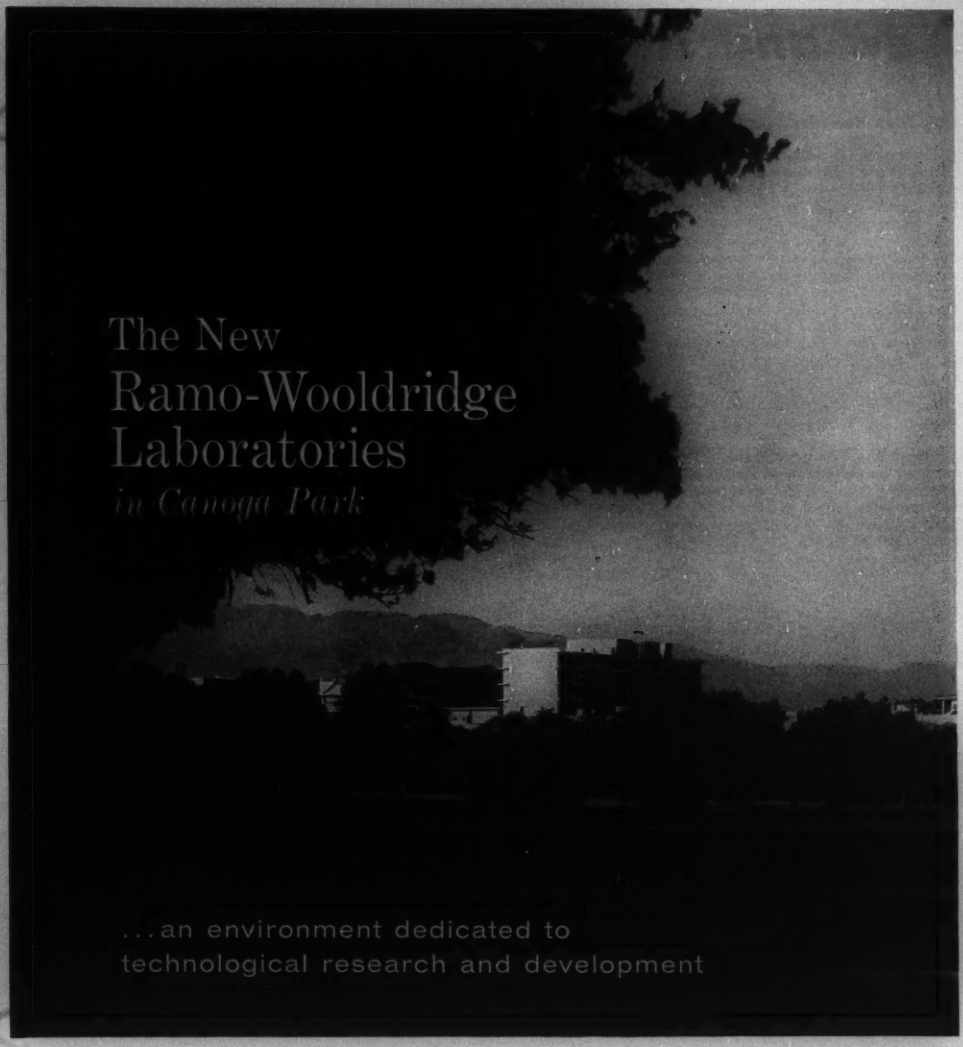
NUCLEAR METALLURGY, Volume 6. Comprising technical papers presented at the 1959 Nuclear Metallurgy Symposium, sponsored by the Metallurgical Society of AIME, the volume is divided into two sections: the behavior of metallic fuel materials and the behavior of the ceramic fuel materials. The first part discusses the fundamentals of fission damage and explains phenomena such as growth, swelling, and radiation-induced phase transformations that limit the useful life of metallic fuels. This is followed by papers on the irradiation behavior of engineering materials. The volume may be purchased through AIME, 29 W. 39th St., New York 18, N. Y. Price is $7.

SCIENTIFIC INFORMATION REPORT. Issued semimonthly by the U. S. Central Intelligence Agency, the report is distributed by the U. S. Department of Commerce, Office of Technical Services, Washington 25, D. C. The report presents unevaluated information extracted from recently received publications of the USSR, Eastern Europe, and China. The information selected is intended to indicate current scientific developments and activities in the USSR, in the Sino-Soviet Orbit countries, and in Yugoslavia, and is disseminated as an aid to United States Government research. Articles abstracted cover a broad range of topics and include astronomy, chemistry, electronics, engineering, medicine, and physics. Annual subscription is $28 ($32 foreign); single copies are $2.75.

ZENER DIODE HANDBOOK. A comprehensive, 130-page manual covering basic theory, design characteristics, and applications for zener (voltage limiting) diodes has been made available by Motorola's Semiconductor Products Division. The handbook is intended to serve as a guide in the use of this new component and includes chapters on the following: characteristics of silicon zener diodes, design considerations, regulated power supplies, surge protection, a-c and d-c amplifiers, temperature compensation and impedance cancellation, and specifications and testing methods. The book contains numerous schematic drawings, tables, and curves. Copies of the handbook are available for $1 from any of the company's distributors, or from Dept. ZDH, Motorola Inc., Semiconductor Products Division, 5005 E. McDowell Rd., Phoenix, Ariz.

WHY AUTOMATION? This report, published by the National Office Management Association (NOMA), is a synthesis of the automation experience of 369 companies with recent automated data-processing machinery installations and deals with the impact of automation in the office. It defines the factors involved in the decision to install automated data-processing systems and their measurable effects thus far on present company growth. Copies of the complete report, which will also include the NOMA Automation Bibliography (a classified compilation of selected articles, booklets, reports, and books published on the subject of automation), are available to nonmembers of NOMA for $5 each from NOMA headquarters, 1931 Old York Rd., Willow Grove, Pa.

RELAY DEFINITIONS AND TESTING PROCEDURES. This 70-page progress report by the National Association of Relay Manufacturers (NARM) presents suggested definitions and test procedures, discusses test equipment and precautions, outlines work yet to be done, and solicits comments and suggestions on work accomplished to date. The report covers dry circuits (low energy switching); measurement of electrical characteristics; contact life testing; environmental testing including temperature, humidity, altitude, and corrosion; vibration testing; and shock, acceleration, and tumbling. Copies of the report are available on request from NARM, attention Prof. C. F. Cameron, P. O. Box 6, Stillwater, Okla.



The new Ramo-Wooldridge Laboratories in Canoga Park, California, will provide an excellent environment for scientists and engineers engaged in technological research and development. Because of the high degree of scientific and engineering effort involved in Ramo-Wooldridge programs, technically trained people are assigned a more dominant role in the management of the organization than is customary.

The ninety-acre landscaped site, with modern buildings grouped around a central mall, contributes to the academic environment necessary for creative work. The new Laboratories will be the West Coast headquarters of Thompson Ramo Wooldridge Inc. as well as house the Ramo-Wooldridge division of TRW.

The Ramo-Wooldridge Laboratories are engaged in the broad fields of electronic systems technology, computers, and data processing. Outstanding opportunities exist for scientists and engineers.

For specific information on current openings write to Mr. D. L. Pyke.

THE RAMO-WOOLDRIDGE LABORATORIES

8433 FALLBROOK AVENUE, CANOGA PARK, CALIFORNIA

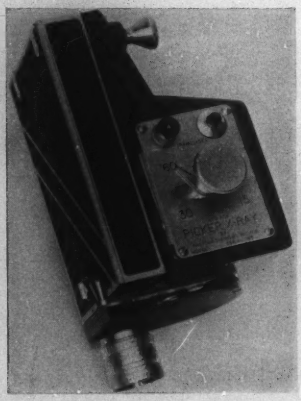
New and Improved Products . . .

Tiny Tape Recorder . . .

Said to be the smallest tape recorder yet developed, this instrument was designed to register missile and satellite information for playback to earth receivers. The entire unit weighs 10½ ounces, will register 16 channels of information on a continuous tape, and requires only 1½ watts to operate. Electronic accessories include transistor timing oscillators, Zener diode, bias supply and bias oscillators, d-c amplifiers, and battery packs. The whole recorder may be inserted in a 3-inch pipe for oil well drilling applications. **Leach Corp., Los Angeles, Calif.**

High-Speed X-Ray Camera . . .

With this high-speed camera, X-ray movies of human internal organs and functions can be taken for diagnostic purposes with minimum hazard to the patient. An epicyclic, quick change gear train provides frame speeds at rates of 7.5, 15, 30, and 60 per second. The camera uses a 100-foot



Courtesy K. Hallock

Kodak Cine Special magazine coupled to a polarized synchronous motor drive which includes a commutator that furnishes shutter phasing. **Photomechanisms, Inc., 6 W. 18th St., Huntington Station, L.I., N.Y.**

X-Ray Gauge . . .

Designed for measurements ranging from foil thickness of 0.0025-inch to plate thicknesses of 1.5 inches, the XactRay gauge uses a sharply pulsed, pencil X-ray beam to measure thickness of steel, copper, brass, aluminum, and other metals at speeds up to 6,000 feet per minute. The new combination recorder-controller offers increased flexibility in controlling up to six points and recording up to 24 points and also features an ability to operate from either one or two separate thermocouples or other inputs per point. **Daystrom Inc., 614 Frelinghuysen Ave., Newark 12, N.J.**

Single Disk 3-Stator Meter . . .

This 3-stator meter designated *P-3* in round construction for measurement of 4-wire wye service completes the line of *P* polyphase meters introduced last year. The unit has sectionalized construction and is easily calibrated. It is furnished in both socket mounting and bottom connected models. **Sangamo Electric Co., Springfield, Ill.**

Heat Insulated Diodes . . .

These silicon diodes are jacketed with Teflon for use in areas where close-quarter mounting procedures are used. In printed-circuit boards, computers, and other data-processing equipment, these high-temperature chemical-resistant jackets permit very close positioning of the diodes while eliminating the possibility of the cases short circuiting to other components or the chassis. Electrical and mechanical properties may be maintained from −67 to +250 C. **International Rectifier Corp., El Segundo, Calif.**

Compression Tool . . .

Nine tons of pressure can be applied for crimping service taps and service-entrance connections with this one-hand-operated compression tool. Power is furnished by a cylinder of liquefied carbon dioxide screwed into the handle of the tool. Over 50 crimps can be made with a refillable cylinder. Safety features include a locking pin to prevent accidental operation of the jaws and a safety blowout disk to prevent excessive cylinder pressure. **The A. B. Chance Co., 210 N. Allen, Centralia, Mo.**

Ultrasonic Impact Grinder . . .

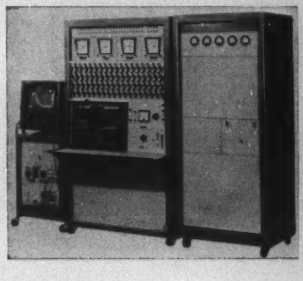
Areas up to 3½ inches in diameter may be cut with this new 2,500-watt impact grinder. Cutting, slicing, drilling, grinding, and trepanning can be accomplished with tolerances of ±0.0003 inch when machining regular or irregular cuts in semiconductors, ceramics, ferrites, carbides, metals, jewels, and other hard or brittle materials. It may also be used effectively to mass machine parts in servo valves. One unusual application is splicing and welding certain hard-to-seal plastics like Mylar that resist being sealed by heat, chemicals, or tape. **Raytheon Co., Waltham 54, Mass.**

High-Fidelity 2-Way Radio . . .

A new Citizens Bank radio with superheterodyne receiver and incorporating other high-fidelity features will provide positive contact up to several miles in the noisiest locations for amateur yachtsmen, construction crew foremen, the farmers, and other users of 2-way radio communication. The highly sensitive receiver can be tuned manually to any one of 23 channels in this band or it may be crystal controlled for any channel desired. A special squelch circuit eliminates receiver noise when the set is standing by for monitoring purposes. **Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N.Y.**

Analog Computer with Digital Advantages . . .

By incorporating the high-speed memory and automatic iteration capabilities of a digital computer with the analog's speed, ease of programming, and improved data output presentation, the DYSTAC makes a wide range of new applications possible. For example, it can solve process



problems theoretically and then apply the answers directly to the control of that process. It can also be used for automatic iteration solution to statistical problems, numerical integration procedures, automatic optimization of least-mean squares, solution of simultaneous second-order partial differential equations and analysis of sample-data systems. **Computer Systems, Inc., 611 Broadway, New York 12, N.Y.**

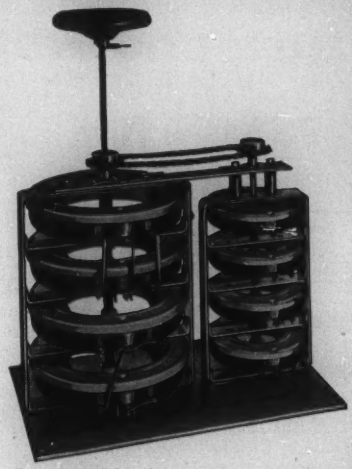
Portable Volt Potentiometer . . .

Typical laboratory and plant applications of this compact, 3-dial potentiometer include measurements of temperature, pH, redox, contact potential, and calibration of d-c ammeters, voltmeters, thermal converters, strain gauges, and similar instruments. Called *8687* or "Baby K-3," its operating range is from 0 to 1.601 volts and from 0 to 0.1601 volts. A central window readout of two decades and slidewire in addition to convenience of operation, high accuracy, and sensitivity are among the advantages claimed for this new instrument. **Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa.**

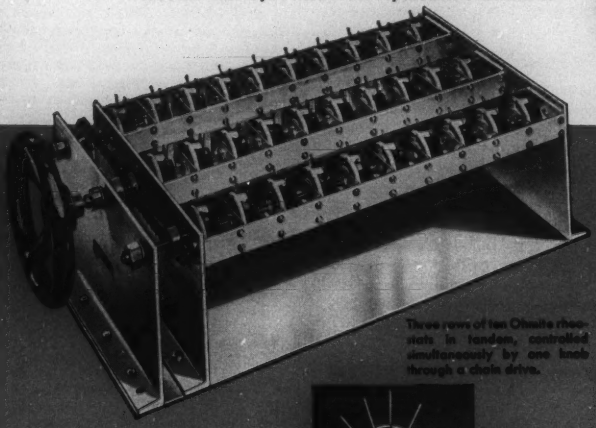
(Continued on page 20A)

OHMITE®
RHEOSTATS
WITH SPECIAL FEATURES
solve many difficult control problems

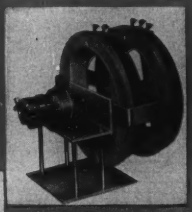
Ohmite offers not only industry's most complete line of *standard* rheostats but also rheostats with a wide variety of *special features*. Illustrated are only a few. All have the distinctive Ohmite design features: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel. You will find the special rheostat feature you need in the dependable Ohmite line.



Two groups of four Ohmite taper-wound rheostats mounted in tandem, controlled by a single knob through a chain drive.



Three rows of ten Ohmite rheostats in tandem, controlled simultaneously by one knob through a chain drive.

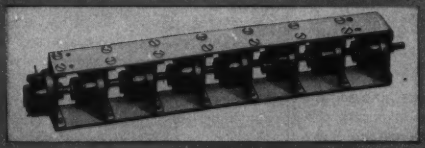


Typical Ohmite motor-driven tandem rheostat assembly.

Locking type bushing with screwdriver slotted shaft.

Example of a 360° rotation rheostat with a wire lead tapped winding.

Ohmite rheostats can be mounted with two, three, or more in tandem for operation by one knob. Controls several circuits simultaneously. Model H and miniature Model E rheostats in tandem save panel space.



Rheostat with tapped winding and sensitive switch, arranged to operate at any preselected position of contact arm.

Ventilated cages prevent mechanical injury, or human contact with electrically "live" parts.

Write on Company Letterhead for Catalog 58.

Call on Ohmite for APPLICATION ENGINEERING SERVICE

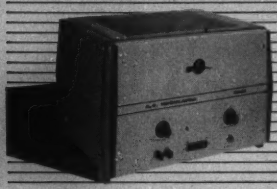
Save valuable engineering time. Team up with Ohmite to solve your resistance problems. Ohmite engineers are resistance specialists. They can quickly analyze your needs and recommend the correct rheostat to fit your application.

OHMITE® Manufacturing Company
3614 Howard Street, Skokie, Illinois
Quality Components

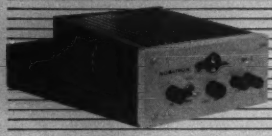
RHEOSTATS RESISTORS TAP SWITCHES
RELAYS VARIABLE TRANSFORMERS DIODES
TANTALUM CAPACITORS R. F. CHOKES

NEW IDEAS IN PACKAGED POWER

for lab, production test, test maintenance, or as a component or subsystem in your own products



0.01% regulation—Why be half safe? You can get a-c line voltage regulation to the exact degree of precision you need from Sorensen. Model 2501 (left) regulates a-c line voltage to ±0.01% at 2500 VA. Other Sorensen a-c models range in precision from meter calibrators to rugged "constant voltage transformers," designed to give you maximum volt-amps per dollar.



Fully-transistorized regulated d-c supplies—The most complete line of transistorized low-voltage d-c power supplies on the market—like the new Model Q6-2 (left)—is offered by Sorensen. Regulation accuracy is ±0.25% (line and load combined). Life is exceptional. Response speed is extremely fast. They come with voltage adjustable over 2:1 range (Model Q Series) in 6, 12, 28 vdc and capacities to 200 watts. Also in 0-36, or 0-75 vdc continuously variable "Rangers" (Model QR Series) of 150-watt capacity.

Here's a d-c workhorse for rack-panel equipment—New Sorensen Model MD supplies feature magnetic regulation, semiconductor rectifiers, capacitance-input filters—and low cost. What's more you get any factory preset voltage you want, from 2.5 vdc to 1000 vdc. Available in 8 sizes from 25 to 3000 watts. No switches, no fuses (short circuited output is not recommended, but is not damaging). Ideal for powering your 19" rack-panel equipment.

Sorensen has many other ideas for packaging power to your needs, including standard off-the-shelf models, both electronic and transistorized, to take care of almost every need for controlled power—whether ac or dc, low or high voltage, low or high current. Ask for the latest Sorensen catalog. And let Sorensen engineers talk over with you a complete power system for your complex electronic equipment.

a-6

Sorensen

SORENSEN & COMPANY, INC.

Richards Avenue, South Norwalk, Connecticut

WIDEST LINE OF CONTROLLED-POWER EQUIPMENT FOR RESEARCH AND INDUSTRY

IN EUROPE, contact Sorensen-Ardag, Zurich, Switzerland. **IN WESTERN CANADA, ARVA. IN EASTERN CANADA,** Bayly Engineering, Ltd. **IN MEXICO,** Electro Labs, S. A., Mexico City.

New & Improved Products

(Continued from page 18A)

New Terminal Strips . . .

A quick snap-fit of the nylon yoke pin into a polypropylene spacer sleeve eliminates the old, time-consuming method of attaching strips to the chassis. Depending on size, these fittings come with one or two nylon yokes assembled. Three sleeve heights are over the chassis. There are seven standard sizes of from 1 to 11 silvered, pretinned notches for quick soldering. **Tektronix, Inc., P.O. Box 831, Portland 7, Ore.**

Scientific Computer . . .

Answers to complex scientific and engineering problems in split seconds are possible with this new IBM *1620* computer. Fully transistorized, the device was designed to meet technological needs for a compact, table-size computer with operating capabilities of much larger systems. Input-output is by means of an electric typewriter and a paper tape reader and punch. A comprehensive library of mathematical and statistical routines provides a fast, simplified method of programming. The magnetic core storage unit has a capacity of 20,000 alphameric digits, each of which is individually addressable and can be made immediately available for processing. **IBM Corp., Data Processing Division, 112 E. Post Rd., White Plains, N.Y.**

Flexible Bus Duct System . . .

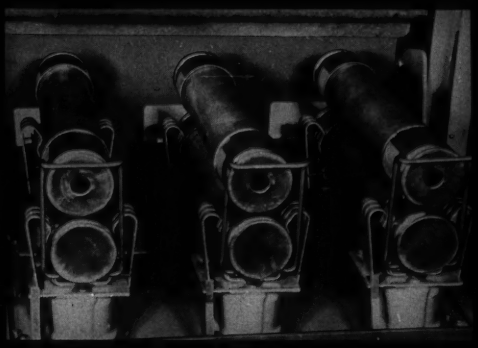
Adaptable for distributing electricity in industrial plants and commercial buildings, *XL* Duct is easy to install and features plug-in power take-off at any place along the line without disconnecting the main power line. It is primarily designed for industries where annual model changes require relocation of machinery and equipment. The ducts incorporate many safety features, and are designed for low voltage drops, while possessing unusual electrical and mechanical strength. Simplified joint construction produces maximum installation economy. The units are available in 10-foot lengths with elbows and short end-pieces. Ratings range from 225 to 1,000 amperes and voltages through 600 volts a-c. **BullDog Electric Products Division, I-T-E Circuit Breaker Co., 7610 Jos. Campau, Detroit, Mich.**

X-Y Plotter . . .

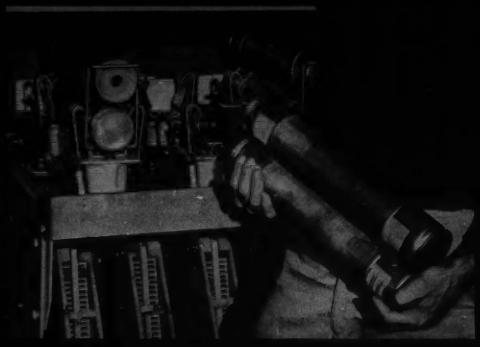
The new *HR-94* XY recorder is designed to operate from differential transformers and may be used to plot very small mechanical movements. With a multiplication factor of 1,000:1 the instrument will readily detect a 20-microinch movement with a total error of less than 0.15%. Signal, reference, and rebalance circuits are 400 cps originating from a built-in tuning fork. **Houston Instrument Corp., 1717 Clay Ave., Houston 3, Texas.**

(Continued on page 24A)

INSTALLS IN HALF THE TIME—Draw-out air break contactor, roomy isolated cable compartments, and increased working space help simplify installation.



LIMITAMP CONTROL IS ISOLATED AUTOMATICALLY—A unique shutter box isolates the starter from high-voltage power when the operating handle is turned to the off position.



INTERRUPTS FAULT IN FIRST ½ CYCLE—Fast-acting, current-limiting fuses interrupt circuit before short circuits cause damage to valuable motors.

NORMAL MAINTENANCE WITH CONTACTOR IN PLACE—All components, including the high-voltage contactor, can be maintained right in the control unit, with complete safety.

LIMITAMP* CONTROL

control utilizes fast-acting current-limiting fuses, ambient-compensated overload relays, and a high-voltage contactor to provide the most "positive" protection for your motors. Proved EJ-2 fuses interrupt a fault in the first ½ cycle, thus reducing damage to valuable motors. The performance of the completely coordinated design has been exhaustively tested in General Electric's high-voltage laboratory to provide the most reliable equipment for your application.

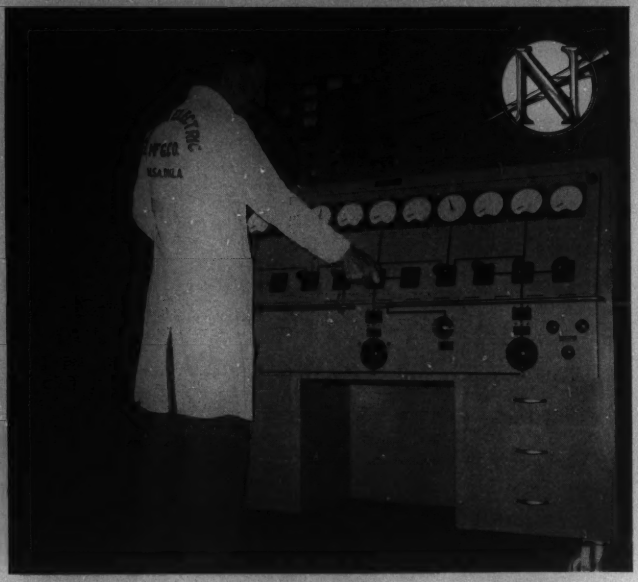
Easier maintenance: Even with these advanced design features, new Limitamp controls are simpler than ever to maintain. All components are accessible from the front for inspection and maintenance—without removing them from the enclosure. A special test circuit is built into each unit—permitting check-out operation before the unit is put into service.

For full information on all-new Limitamp motor control, contact your G-E Apparatus Sales Engineer or Agent today. Or write Sect. 783-10, General Electric Co., Schenectady, N. Y., for Bulletin GEA-6893. Industry Control Dept., Roanoke, Virginia.

*Reg. trade-mark of General Electric Company.

Progress Is Our Most Important Product

GENERAL ELECTRIC



NELSON SWITCHBOARD TESTING ASSURES PERFECT OPERATION

Nelson makes certain at the factory that your switchboards and switchgear will work right. This quality control is now possible because the . . .

NEW NELSON SWITCHBOARD TESTER DUPLICATES FIELD OPERATING CONDITIONS

Developed by Nelson to test metering and relaying circuits of completed switchgear before shipment, this device tests potential and current circuits.

The performance of the switchboard is accurately measured. Gone is the guesswork of the old-fashioned continuity tests that showed only whether or not the switchgear was wired as shown on the wiring diagram.

This test gives both Nelson and the customer the satisfaction of KNOWING that the equipment is *right* as it leaves Nelson's plant, and is going to function in the field when properly installed.

a major source of electrical control equipment for industry

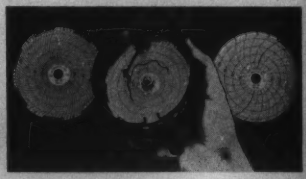
NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

New & Improved Products

(Continued from page 20A)

Recording Thermometer . . .

Weighing less than a pound, this portable recording thermometer employs a dry stylus so that it can be used anywhere to record temperature-time changes. Powered by a spring wound clock movement, the device is small enough to be packed with goods being shipped and will record in any position. For recording



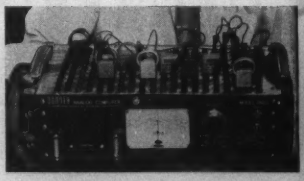
temperature in liquid or wet environments, the instrument can be encased in a thin polyethylene bag. Time ranges are available for one or seven days and temperatures either from 20 F to 220 F, or from —40 F to 160 F. **Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.**

Fail-Safe Annunciator . . .

The operator can immediately tell whether an "off-normal" condition is the result of field conditions or instrument component failure with this fail-safe annunciator. Two lamps per annunciator point are used instead of one. A red lamp indicates a field abnormality while a white lamp shows a component failure and also doubles as a running lamp during such failure. **Panalarm Division of Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.**

Miniature Computer . . .

Said to be the smallest full-fledged analog computer yet made, this 10-amplifier model weighs just 23 pounds and may be used to study almost any physical system that can be described by linear differential equations. Designed for educators,



engineers, and scientists, the unit can solve up to a seventh order differential equation or a ninth degree Laplace transform. For solving more complex problems, up to three model *3,500* computers may be slaved together for 10-, 20-, or 30-amplifier operation. **Donner Scientific Co., Concord, Calif.**

(Continued on page 28A)

Both the instantaneous and time-delay overcurrent units are torque-controlled by the directional unit.

Taps on the instantaneous unit facilitate setting and maintain a low burden level at any tap value over the entire current range. The cylinder unit design is insensitive to transients.

The time-delay overcurrent unit is available with any of seven different time-curve characteristics, plus a wide range of selectivity in time dial positions and minimum operating current.

For complete information on the new IR relays, call your Westinghouse salesman. Or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40523

YOU CAN BE SURE...IF IT'S

Westinghouse

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV FRIDAYS

REMOTE INSTRUMENTATION & CONTROL

Telemeter
CONTINUOUSLY
from Remote Points

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Compatible with most Transducers and Recorders

Tone Multiplex plus Telemetering in Single Package

Includes 10%, 50%, and 90% System Check Voltages

Accurate HIGH-SPEED Analog Telemeter for VOLTS AMPS WATTS PRESSURE FLOW TEMPERATURE etc.

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, or other transducers with a DC mv output, to an output of 10 to 30 cps. If multi-channel operation over a single communication circuit is required, the 10 to 30 cps signal is used to modulate a built-in frequency shift tone channel. The Model 1090 Telemeter Receiver detects and demodulates the transmitted signal and generates a DC current or voltage which varies in exact accordance with the telemetered functions. The receiver output may be directly applied to either recorders, indicating instruments, or both.

The equipment is conservatively designed for continuous duty operation. The over-all accuracy of the Telemeter is 1% with a speed of response of one second.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

WE CAN HELP YOU — Our Applications Department is ready to assist you in your control, telemetering or communications problem.

Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U. S. A.

New & Improved Products

(Continued from page 24A)

Tracing Film . . .

Duratrace is a new and improved tracing film that is low in cost, highly durable, has erasing qualities equal to the finest tracing cloth, and provides an excellent surface for pencils up to 5H. The film has a unique surface on a Mylar base, is waterproof, and will not become brittle or yellow with age. A soft rubber eraser is satisfactory for making pencilled or typed corrections where 25 erasures may be made on the same spot without destroying the drawing surface. **Ozalid Division, General Aniline and Film Corp., Johnson City, N.Y.**

Thermal Endurance Plotting Paper . . .

Two uniform graph sheets are now being produced that will allow much greater increase in uniformity and permit easier comparison of data presented for thermal endurance of insulating materials and systems. In many cases such data follow quite closely the chemical reaction rate theory and a straight line plot results. In both sheets, time (t) is plotted vertically in a 4-log cycle form from 10 to 100,000. On sheet *259-270 G*, temperature may be plotted horizontally from 100 to 300 C and on sheet *259-271 G* from 100 to 400 C. **Keuffel & Esser Co., 300 Adams St., Hoboken, N.J.**

Glass Base Epoxy Laminates . . .

Two new general purpose grades of epoxy-impregnated glass base laminated plastics are available in plain sheets or as Di-Clad copper clad sheets for printed circuit applications. Designated *GB-28EV-2* and *GB-16EV-2*, these new grades are designed for electrical insulation requiring low electrical loss properties and good arc resistance and dielectric strength. Sheet sizes are 38 by 38, and 38 by 42 inches. In thickness, *GB-16* is available from 0.010 to 1/8 inch, and *GB-28* from 1/32 to 1 inch inclusive. **Continental-Diamond Fibre Corp., Newark, Del.**

Packaged Power Center . . .

A line of indoor unit substations rated up to 500 kva transforms and controls power at primary voltages of 5 or 15 kv to secondary distribution voltages at the point of use. The maximum over-all dimensions of the unit are 78 inches high, 98 inches long, and 42 inches deep, making possible conservation of valuable floor space. Because the transformers are conservatively rated and mounted on vibration dampeners, the noise level is below NEMA standards making these power centers especially suitable for use in occupied areas or wherever personnel work close by. **Federal Pacific Electric Co., 50 Paris St., Newark 1, N.J.**

(Continued on page 30A)

Alcoa Aluminum ...easy to join by any method!

By incorporating Alcoa® Aluminum into your products, you'll enjoy many new advantages which are unobtainable with conventional metals. This fact is being profitably proved by manufacturers and fabricators, whatever the joining method . . . welding, brazing, bolting or compressing.

For example, Alcoa Aluminum is low in cost . . . lighter in weight . . . easier to handle . . . nonmagnetic . . . corrosion resistant . . . strong in alloys . . . offers more current-carrying capacity per pound . . . is easy to spin, form, bend, roll . . . can be cast, forged, extruded or drawn.

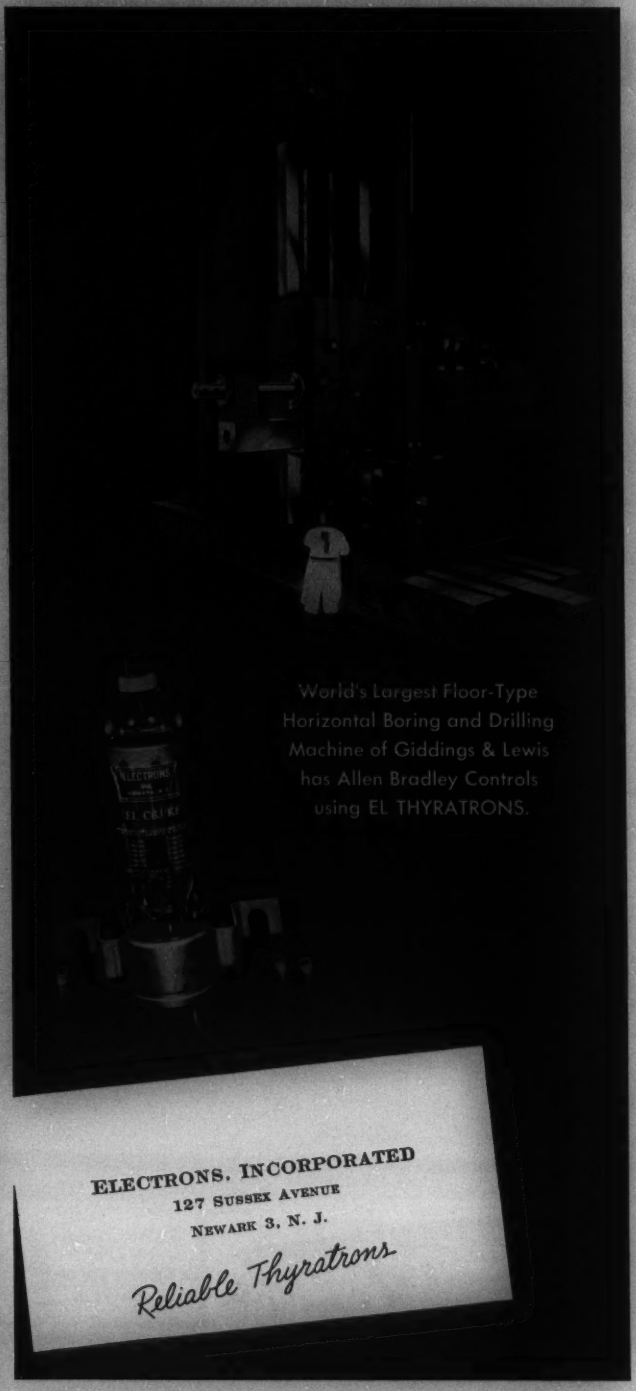
Ask your Alcoa sales engineer to show you how you can put the benefits of Alcoa Aluminum into your products. Aluminum Company of America, 2114-J Alcoa Building, Pittsburgh 19, Pennsylvania.

Compression welding of Alcoa Aluminum is especially suited for fast, strong welds of nonheat-treatable alloys in the annealed condition. This method is utilized by manufacturers in several industries for making lap welds in sheet and foil, butt welds in tube and sheet. Butt welds are also obtainable in bars or simple extruded shapes. No flux is required . . . resistance to corrosion is as good as the parent metal . . . heat cycle tests confirm that sound electrical connections in both aluminum to aluminum and aluminum to copper may be accomplished.

ALCOA ALUMINUM

Your Guide to the Best in Aluminum Value

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV



New & Improved Products

(Continued from page 28A)

Solar Furnace . . .

The *SF-9* for use in research and testing is a versatile high-temperature solar furnace available in a do-it-yourself kit form or fully assembled. The apparatus, which has a focal diameter of 5 feet, can create temperatures up to 6741 F in just a few seconds with flux densities up to 365 calories per square centimeter per

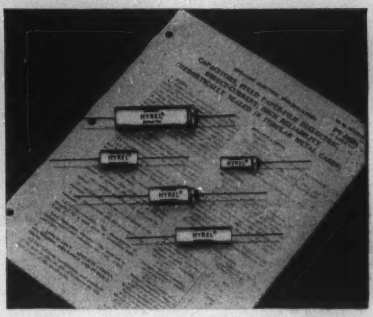
second—when the sun is shining, of course. Fully equipped with automatic tracking system, remote controlled sample positioner, and temperature adjustment, it can be mounted on a mobile or stationary platform. **Waltham Precision Instrument Co., 221 Crescent St., Waltham 54, Mass.**

Frequency Sensing Governor . . .

Model *EFG*, a universal electric governor for use on diesel and gasoline engines, steam and gas turbines is designed for constant speed control over a 10% range in 400 cycle service, and over a 30% range in 50/60 cycle service. The sensitivity and response characteristics of the governor are measured in milliseconds and the frequency circuit operates within 3 milliseconds when the smallest speed change occurs. Full movement of the throttle from closed to open position is accomplished in 0.035 seconds. Another important advance in the new unit is the development of a transducer element which replaces the wire-wound feedback potentiometer. **Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh 30, Pa.**

Toggle Switch . . .

Here is a precision-made toggle switch that contains four poles yet occupies less than 1 cubic inch of space below the panel. It was designed for aircraft, military, and other applications requiring compact control panels. All exposed metal parts are either stainless steel or treated for corrosion resistance. Each pole is rated at 6 amperes, 125/250 volts a-c. Weight is approximately 1 ounce. **Electrosnap Corp., 4220 W. Lake St., Chicago 24, Ill.**



MISSILE-READY CAPACITORS

—thanks to Sprague's PV-100A

It has been more than three years since Sprague originated Specification PV-100–*the first high reliability capacitor specification for missiles and other critical applications.* This specification and a later revision, PV-100A, have proved so comprehensive and so successful in providing "the highest order of reliability known to the capacitor industry" that their provisions are currently reflected in *every* military specification covering high reliability capacitors. This is a distinction shared by no other capacitor manufacturer.

The capacitors manufactured by Sprague to PV-100 and PV-100A standards have amassed a record of reliability far in excess of original expectations. On high frequency vibration, shock, and other environmental tests, failure rate has been almost zero. On accelerated life tests (250 hours at 140% rated voltage, 125° C) *failure rate has been less than .05%.* This performance is virtually impossible to beat . . . now and for some years to come. But Sprague doesn't stop here. The company's research on materials, processes, and controls is now more intensive than ever. Sprague knows that only through continuous research can high reliability be made *higher.*

If you're interested in the fine points of high reliability capacitors, call your Sprague District Office or Representative. Or write letterhead request for Sprague's Hyrel Bulletin 2900A and Specification PV-100A to Technical Literature Section, Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

SPRAGUE®

THE MARK OF RELIABILITY

SPRAGUE COMPONENTS:

CAPACITORS • RESISTORS • MAGNETIC COMPONENTS • TRANSISTORS • INTERFERENCE FILTERS • PULSE NETWORKS
HIGH TEMPERATURE MAGNET WIRE • CERAMIC-BASE PRINTED NETWORKS • PACKAGED COMPONENT ASSEMBLIES

OPPORTUNITIES
With A
Growth Company

A progressive rapidly expanding manufacturer in the field of Xerography (a method of physical photography based on solid state and electrostatic phenomena) has outstanding opportunities for:

Senior Project Physicists

PhD or MS in solid state physics, preferably with experience or training in photo-conductivity and/or single crystal electronic devices.

Also

THEORETICAL PHYSICIST

With 2-3 years experience in analysis of semi-conductor devices — especially single crystal diodes and transistor devices.

Openings exist in the field of photo-conductivity and semi-conductivity as applied to electro-optical devices.

Emphasis will be on the study of the properties of photo-conductive materials and the relationship of transport mechanisms to device behavior. Individual will have major responsibility for planning, supervising and carrying out experimental programs.

Kindly send resume and salary requirements to:

Fred A. Wetterings
Industrial Relations Division

HALOID XEROX, INC.
P.O. Box 1540 Rochester 3, New York

ENGINEERS
DESIGNERS
RELOCATE
LOS ANGELES

Senior Engineers

Liberal relocation allowance will be paid for you and your family. Present requirements are for top Senior Engineers with degree and approximately six years electrical or mechanical engineering experience on steam power plants or other heavy industrial facilities.

Designers

Relocation allowance as above outlined will be allowed for designers with at least 6 years mechanical or electrical layout experience on steam power plants or other heavy industrial facilities.

Send Professional Resume to:
Grayson Arnold,
Chief Engineer

BECHTEL CORPORATION
4620 Seville Avenue
Vernon, California

In New York City, a personal interview can be arranged by phoning Paul Keating, MUrray Hill 7-7100.

In San Francisco, a personal interview can be arranged by phoning Bill Anderson, DOuglas 2-4032.

Industrial Notes...

BICC–Burndy Ltd. Norwalk, Conn. . .

Formation of BICC–Burndy Ltd., jointly owned by Burndy Corp., Norwalk, Conn., and British Insulated Callendar's Cables Ltd., London, England, to manufacture and sell Burndy electric connectors in the British Commonwealth has been announced. To BICC's experience and facilities the new company will add Burndy's design and engineering background in all types of electric and electronic connectors. The full line of Burndy connectors and installation tooling, for electric power transmission and distribution, electrical and electronic products, and aircraft and missiles, will be marketed by BICC–Burndy throughout the British Commonwealth except Canada, Australia, and New Zealand, where other arrangements are in effect.

Remington Rand New York, N. Y. . .

Magnetic tape, with its greatly increased speed of operation, its economy, and its enlarged "memory" storage capacity, has been adapted to Univac solid-state computers, the Remington Rand Division of Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y., announced. Present Univac solid-state systems use only punched cards. The addition of magnetic tape, either metallic or plastic, will allow business, governmental, and scientific institutions to capitalize much more fully on the inherent advantages of solid-state design. Known as the Univac Solid-State Magnetic Tape system, the new equipment consists of a central processor, magnetic tape "Uniservos," a tape synchronizer, a card reader, a read-punch unit, and a high-speed printer.

Digital Instrument Laboratories Los Angeles, Calif. . .

Digital Instrument Laboratories has completed moving plant facilities to a new location at 5115 Via Corona, Los Angeles, Calif., to keep up with expanding business. Within the next year, the company expects to double its engineering staff. Precision oscillators, high-speed multiplexers, and specialized digital electronic devices for military and commercial application are manufactured by the company.

(Continued on page 40A)

Investigate the Widest Variety of Openings in Recent Years

at the Knolls Atomic Power Laboratory

For the first time in recent years, current openings here extend into disciplines generally considered outside of the traditional nuclear areas. As a result, excellent opportunities exist today for men interested in entering the nuclear field for the first time, as well as for recent graduates and, of course, experienced nuclear engineers and scientists. If you've been thinking of exploring professional opportunities at KAPL, we suggest you make your initial inquiry today.

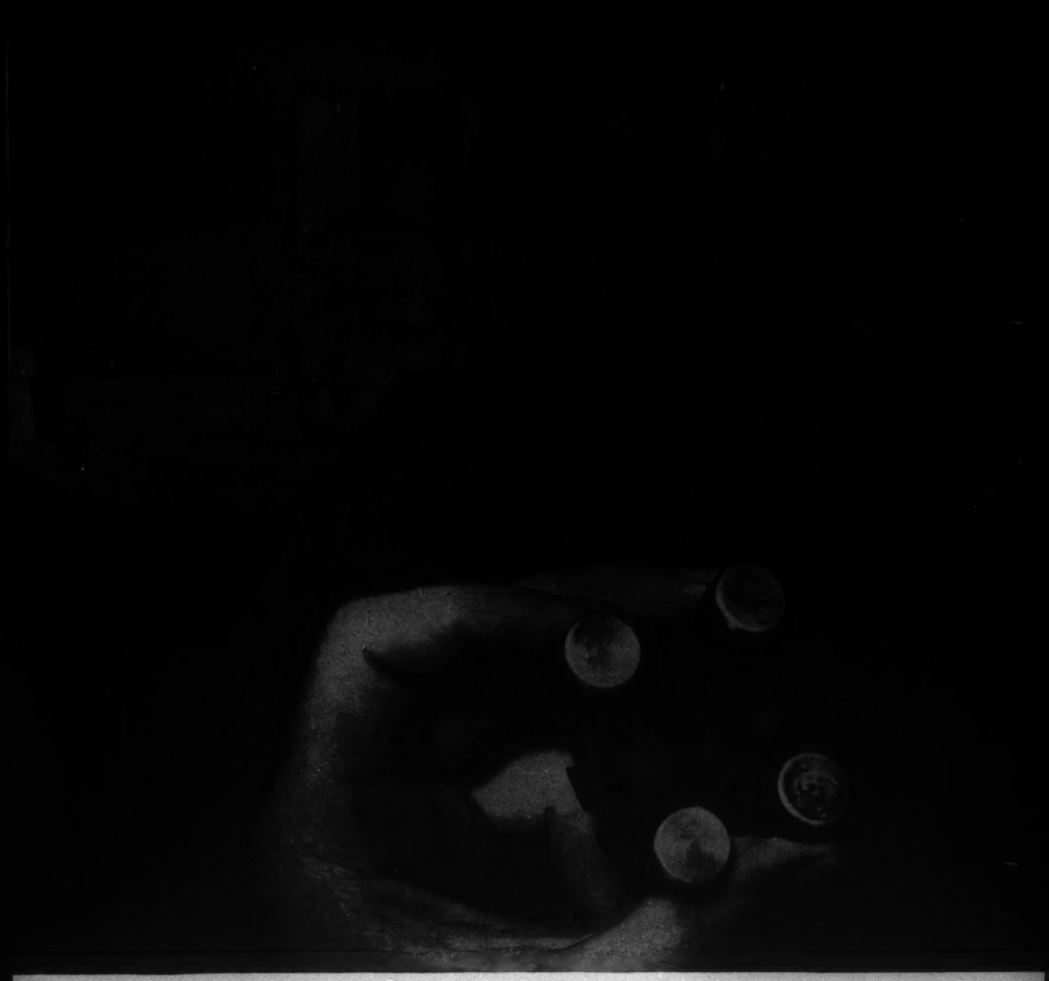
Current Openings:

- Primary & secondary systems design
- Reactor operation
- Heat transfer, fluid flow
- Powerplant performance evaluation
- Powerplant & reactor instrumentation
- Powerplant & reactor controls
- Control drive design
- Electronic equipment development

U. S. Citizenship Required

Forward your resume in confidence, including salary requirement. Please also state your job interests. *Address:* **Mr. A. J. Scipione, Dept. 27-ML.**

Knolls Atomic Power Laboratory
OPERATED FOR A E C BY
GENERAL ELECTRIC
Schenectady, N. Y.



How to avoid a common cause of machine downtime

Even well designed and engineered machines can turn out to be big headaches. Common cause: Downtime due to excessive maintenance of electric controls.

Electrically operated machinery is only as good as the controls which govern its operation. Minimum electrical maintenance means less machine downtime.

Hint: To insure maximum operating efficiency for *your* machinery, check the above photograph. It shows the contact tips (at right) from a Clark Type "CY" A-C Motor Starter after one year of continuous service with frequently as many as 5,000 operations per hour. Compare them with the new, unused tips at left above.

See for yourself that except for slight discoloration and minute pitting the used contact tips show very little evidence of wear even after one year of steady operation. Many more years of reliable, maintenance-free (and downtime-free) service are assured.

Clark's exclusive "arc quenching" principle, which works through the use of strong, multi-turn magnetic blowouts and double-break contacts, is the answer.

The action of the magnetic field not only forces the arc to rotate, moving it continually over contact surfaces, but tends to "quench" it at the same time. As a result, there's less wear on contact tips and a substantial reduction in maintenance requirements – much less machine downtime.

There are many more good reasons why the Clark Type "CY" Starters will control your machines better – help them to put their "best foot forward" and keep it there. For *all* the facts on Clark "CY" Starters, as well as space-saving "PM" Relays and other controls in Clark's "standard of quality" line contact your nearest Clark Controller sales office or distributor. Or, write direct.

982

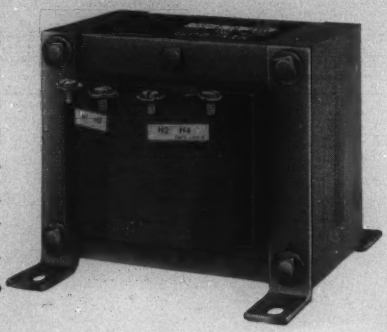
The CLARK CONTROLLER Company

Everything Under Control • 1146 E. 152nd St. • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

New control circuit transformer has a drop below rated voltage of only 5% at 1,000% inrush current

The extra capacity enables you to specify transformer size according to your sealed volt amperes with few exceptions. Savings of initial cost and panel space will result because you can often use a smaller unit. New Hevi-Duty Type SZO transformers range from .050 to 5 KVA.



Write for Bulletin 300

HEVI-DUTY

A DIVISION OF BP C BASIC PRODUCTS CORPORATION

HEVI-DUTY ELECTRIC COMPANY, MILWAUKEE 1, WISCONSIN

Industrial Furnaces and Ovens, Electric and Fuel • Laboratory Furnaces • Dry Type Transformers • Constant Current Regulators

EXTRA

Sel-Rex®

CUSTOM ENGINEERED

RECTIFICATION

We don't make pop-up toasters or television sets—our business is Semiconductor Power Conversion Equipment and Systems. This intense specialization assures you of the best rectifier equipment it is possible to build—plus the flexibility of modifying designs to meet specific, exacting requirements. Such valuable EXTRAS are evident in every Sel-Rex Rectifier installation. Send for FREE "GUIDE" to Industrial Rectifier Equipment.

- Germanium
- Silicon
- Selenium

Rectifier Division

SEL-REX CORPORATION

NUTLEY 10, NEW JERSEY

Representatives in Principal Cities

"Complete Semiconductor Power Conversion Systems for any AC to DC application"

Industrial Notes

(Continued from page 38A)

The Electric Autolite Co. Toledo, Ohio . . .

Definite steps to enter new fields have been taken by the Electric Autolite Co., Toledo 1, Ohio, which has assumed a new corporate name and symbol. Now Autolite will be spelled without the hyphen, and the new corporate symbol consists of a four pointed star extending beyond a concentric circle. The significance of the elimination of the hyphen in the name Autolite is that the new spelling better signifies the Autolite of today which is much more diversified in comparison to the time when it was solely a supplier for the automotive industry.

Electronics Funding Corp. New York, N.Y. . .

Announcement has been made of the formation of Electronics Funding Corp., 90 Broad St., New York 4, N. Y. The objective of Electronics Funding Corp. is to supply not only necessary finance in the early stages of a company's development but to make available where required, assistance in engineering, accounting, law, public relations, and advertising.

Instrument Systems Corp. College Point, N. Y. . .

As part of its over-all growth and diversification program, the corporate name of Waldorf Controls Corp. has been changed to Instrument Systems Corp. The firm, engaged in design, development, and manufacture of electronics, precision mechanisms, and instrumentation systems for military and industrial applications, also announced the acquisition of all facilities and assets of the G. B. W. Manufacturing Co., a leading producer of aircraft precision instruments and mechanical components. Combined facilities and personnel have been consolidated in a modern 22,000-square-foot plant at 129-07 18th Ave., College Point, L. I., N. Y.

Aluminum Co. of America Pittsburgh, Pa. . .

Copper wire, traditionally the sole medium used to wind electromagnetic coils, today is yielding its exclusive dominance of this major market to a new material, aluminum foil or sheet strip conductor. Current activities by over a dozen coil manufacturers indicate that aluminum strip is about to make sizable inroads into the coil field. Present indications are that aluminum-strip-wound coils are about to become a general market item. Currently in regular production, or scheduled to be so, are the following types of strip-wound coils: dry-type distribution transformers, aircraft and electronic solenoids, motor vehicle alternators, clutch coils for heavy-duty equipment, lifting magnets, and arc welding equipment.

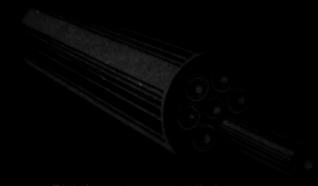
(Continued on page 42A)

FROM TRANSMITTING KILOWATTS TO TRANSFERRING BTU'S

Copper and Aluminum electrical connectors

Wolverine Trufin—the integrally finned condenser tube

Prime surface tube in copper and aluminum



Rigidly quality-controlled tubing for transmission cables

WOLVERINE TUBE PRODUCTS FOR THE ELECTRICAL INDUSTRY

When a manufacturer of transformer oil coolers needs condenser tubing he can obtain exactly what he requires from Wolverine Tube. Wolverine's condenser tube line-up includes both prime surface tubing and capacity-boosting Wolverine Trufin —the integrally finned tube. If, on the other hand, his requirements call for small diameter tubing for transmission line use Wolverine has it, too—in a wide range of wall thicknesses and alloys in both copper and aluminum.

For the production of tubular-shaped parts for electrical use, Wolverine maintains complete fabrication facilities. Included are such techniques as finning, spinning, beading, bending, coiling, extruding, flaring, and expanding—to name but a few of the possibilities. Wolverine copper and aluminum tube is also widely used for fabrication into electrical connectors.

Next time you need tubing—or technical counsel concerning tubing and its uses—remember that the finest in both are available at Wolverine Tube. For the complete story write for your copy of the Wolverine General Products Catalog.

CALUMET & HECLA, INC.
ALLOY CASTING DIVISION
TITANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION

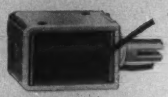
In Canada
CALUMET & HECLA (CANADA) LIMITED
WOLVERINE TUBE DIVISION
CANADA VOLCANIZER & EQUIPMENT CO. LTD.
UNIFIN TUBE DIVISION

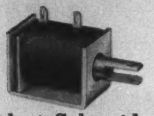
WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17248 Southfield Road
Allen Park, Michigan
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.
Export Department, 13 East 40th Street, New York 16, New York.

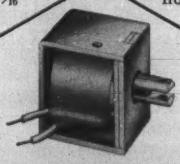
EVERYTHING UNDER CONTROL
with
SOLENOIDS
by
GUARDIAN





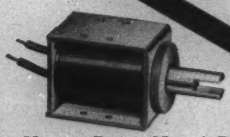
No. 22 D.C. Guardian's "mighty midget". Only ¾" x ¾" x 1⅛" size. Stroke ranges from 1/32" to 5/16" and lifts up to 24 ounces. Available D.C. voltage only for intermittent or continuous duty.

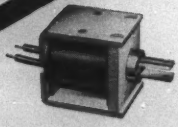
No. 24 A.C. Midget Solenoid. Only 1¼" x 1" x ⅞". Stroke ranges from 1/16" to 5/8" with lift over 19 ounces. Available for intermittent or continuous duty in any A.C. voltage up to 230 V.A.C.



No. 28 A.C. or D.C. MIDGET SOLENOID.

Announcement of this new Guardian midget solenoid will be greeted with eager interest by design engineers. It is most versatile. Has tapered plug and plunger for greater power. Adjustable stroke 1/16" to ½". Lift of over 41 ounces. Only 1⅛" x 1" x 1 3/16". Available A.C. or D.C.; intermittent or continuous duty.



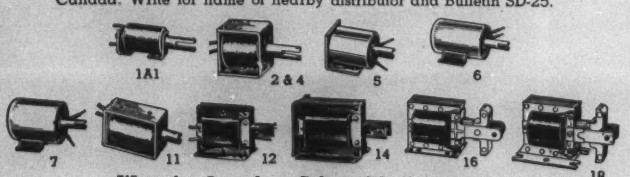


Heavy Duty No. 4 D.C. A version of Guardian's No. 4 solenoid. Has added power lift up to 9 pounds achieved by use of tapered plug and plunger, and special frame. Adjustable stroke ⅛" to ¾". Available for continuous or intermittent duty with D.C. voltages up to 110 V. D.C.

Heavy Duty No. 2 A.C. or D.C. A new version of Guardian's well-known standard No. 2 solenoid having greater power and much longer life expectancy well in excess of 15 million operations. Adjustable stroke 1/32" to ¾". Lifts more than 95 ounces. Available for A.C. or D.C.; intermittent or continuous duty.

Guardian offers the most complete, flexible and versatile line of solenoids ranging from midgets to heavy duty laminated types and for intermittent or continuous duty. Available with "Permaseal" encapulated coils and in D.C. units for 400 cycle operation.

LARGE SELECTIONS of Guardian Solenoids are carried in stock by Franchised Electronic Parts Distributors in the U. S. and Canada. Write for name of nearby distributor and Bulletin SD-25.



Write for Guardian Solenoid Bulletin SOL-8

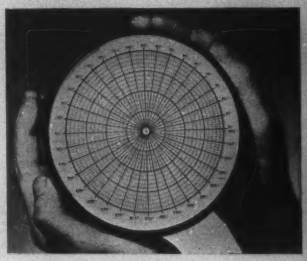
GUARDIAN ELECTRIC
MANUFACTURING COMPANY
1626-P W. WALNUT STREET, CHICAGO 12, ILLINOIS

Industrial Notes

(Continued from page 40A)

Du Mont
Clifton, N.J. . .

A simplified, inexpensive method for applying black scale patterns on the inside of the face plate of cathode-ray tubes is reported by the Chemical Laboratory of the Electronic Tube Division of Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N. J. Engineering models of tubes of this type have been made, and the company states that



it is perfectly feasible to apply the process to production quantities of tubes for particular applications. Illustrated is a polar co-ordinate scale as applied on the inside of the face plate of a 5-inch diameter Du Mont cathode-ray tube. Parallax-free precise readout is thus possible, and the black scale lines offer maximum contrast for viewing under low ambient light conditions.

Harvey-Wells Electronics, Inc.
East Natick, Mass. . .

The Research and Development Division of Harvey-Wells Electronics, Inc., now occupies a new building in the East Natick, Mass., Industrial Park, according to an announcement from R. A. Mahler, president of the New England electronics firm. Located about 15 miles west of Boston the new facility is to contain research, engineering, manufacturing, and marketing offices of the expanding Research and Development Division.

National Semiconductor Corp.
Danbury, Conn. . .

Manufacture of transistors by production personnel has started in the new controlled conditions plant of National Semiconductor Corp., Danbury, Conn. Developed for low power level amplification in electronic equipment for missile, aircraft, and industrial uses, the transistors now in production are the p-n-p silicon alloy small signal type. They meet stringent military qualifications for low noise amplification, low leakage, and stability under extreme environmental conditions.

(Continued on page 48A)

FIRST REAL CHANGE IN AB BREAKERS SINCE 1927*

NEW Ease of Operation — Smooth, easier throw... no more cumbersome handle extension.

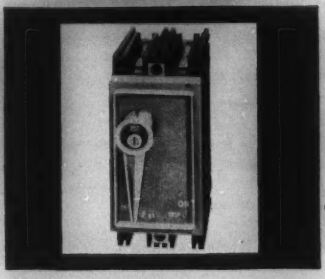
NEW Safety—Rotary handle mechanism is a built-in part of the breaker. Assures positive indication... positive operation.

NEW Economy— Eliminates excess linkage. Means simpler installation, reduced maintenance... as well as greater safety.

NEW Locking Feature — Key-handle lock off is standard...accommodates three padlocks as well.

REVOLUTION

Plus a NEW Look—Breaker face styled by Raymond Loewy Associates for best appearance in any location.



Write today for illustrated Bulletin #1425, Federal Pacific Electric Company, General Offices: Dept. 403, Newark 1, New Jersey.

*In 1927 the first practical molded case circuit breaker was introduced. It established the general standard that was to govern circuit breaker design for the next 32 years. Now—through imaginative engineering, Federal Pacific establishes a new standard.

FPE **FEDERAL PACIFIC ELECTRIC COMPANY**

The Best in Electrical Distribution and Control Equipment

ENGINEERS—Electrical, Mechanical, Industrial

WESTERN ELECTRIC

Is Augmenting

Its Professional Staff

Western Electric has openings for men of superior professional ability. Present areas of activity that afford opportunity to utilize your full technological skills are:

■ NIKE ZEUS ANTI-MISSILE MISSILE SYSTEM ■ MISSILE GUIDANCE SYSTEMS ■ ASSOCIATED GROUND CONTROL RADAR SYSTEMS ■ FIRE CONTROL RADAR ■ UNDERWATER DEFENSE SYSTEMS ■ DIGITAL COMPUTERS ■ WAVEGUIDES AND GYROS ■ HIGH PRECISION ELECTRONIC COMPONENTS AND SOLID STATE DEVICES

You are invited to discuss with us how your previous training and experience can fit you for an important career position in one of these engineering areas:

- Development
- Project
- Test Planning
- Test Set Design
- Pilot Line Manufacture
- Tool Design
- Product Design
- Standards
- Technical Publications
- Field Engineering

Also Openings For:

- Technical Writers
- Engineering Associates

Positions are available at these Western Electric Locations: Winston-Salem, Greensboro and Burlington, North Carolina Laureldale, Pennsylvania and Whippany, New Jersey

For a personal interview in your area or at one of the above locations, address your resume to: Mr. T. R. Lannon Engineering Employment Manager, Dept. 924B.

Western Electric

MANUFACTURING AND SUPPLY UNIT OF THE BELL SYSTEM

Lexington Road, Winston-Salem, North Carolina

Industrial Notes

(Continued from page 42A)

Westinghouse Electric Corp. Staunton, Va. . .

A single setting of a thermostat will maintain pleasant home temperatures all year long for families of officers and airmen living in the new $14 million housing project, consisting of 800 dwelling units, at the Myrtle Beach Air Force Base in South Carolina. Each of the homes is cooled in the summer and heated in the winter by an individual heat pump which automatically makes the transition from season to season. The housing project is equipped with 2-ton and 3-ton units which were built by the Westinghouse Electric Corporation's Air Conditioning Division, Staunton, Va. These units transfer or "pump" heat from inside air to the outside air in cooling the home during the warmer months, and automatically reverse the process by extracting heat from the outdoor air during the winter.

National Research Corp. Cambridge, Mass. . .

A newly developed research facility, recently announced by National Research Corporation, 70 Memorial Dr., Cambridge 42, Mass., will permit realistic testing of large satellite and space vehicle components and may take much of the guesswork out of space hardware design. The Cambridge organization disclosed successful operation of what is believed to be the first large space test facility in this country which can reproduce the extreme vacuum encountered by satellites at orbit altitudes in excess of 400 miles. It has reached pressures as low as one ten-trillionth of the normal earth's atmosphere (8 by 10^{-10} millimeters of mercury). The company operates the facility which includes several test chambers in its Cambridge plant for Government and industrial laboratories on both a service and research basis.

Public Service Electric & Gas Co. Newark, N.J. . .

Work on the rebuilding of its overhead electric distribution system as a safeguard against future storm damage has been started by Public Service Electric and Gas Co., 80 Park Pl., Newark 1, N. J., in sections of certain municipalities in its territory. This is part of a long-range state-wide plan instituted by the company which, when completed, will greatly reduce the number of electric outages caused by snow, sleet, and windstorms and also will accelerate restoration work should storm damage occur. These, and other sections of the state where overhead distribution rebuilding will be carried out, have been selected because of the density of trees and severity of storm damage experienced in the past and expected as a future possibility.

ELECTRONIC-ELECTRICAL ENGINEERS

Are you enjoying these advantages in your present position?

☐ **Space-age assignments.**

Boeing's extensive systems management experience and its space-age orientation have laid the foundation for continuing growth and leadership. Underway at Boeing are advanced space-probe research projects, and lunar, orbital and interplanetary systems studies. Electronic and electrical engineers find at Boeing assignments of tremendous scope and professional reward in radar, infrared, antennas, guidance and control, instrumentation, and communication.

☐ **Advanced research facilities.**

Boeing's research, development and engineering facilities are among the most varied, extensive and complete in the industry. If your field is design or development, you'll be backed up by research scientists working in ion and plasma rockets and fields covering the full spectrum of electronic requirements of advanced, integrated systems. If your prime interest is research, you'll be working with up-to-this-minute equipment. In addition, the Boeing Scientific Research Laboratories is staffed to develop new and fundamental knowledge at the frontiers of science.

☐ **Opportunity for Advancement.**

Spacecraft and advanced missile projects—including Minuteman solid-propellant ICBM—are expanding at Boeing, creating an increasing demand for electronic-electrical engineers capable of moving up to positions of greater responsibility and income. To help engineers get ahead faster, Boeing maintains a company-paid graduate study program, and conducts regular personal merit reviews to assure you a continuing opportunity for individual recognition and advancement. Boeing also carries out other company programs designed especially to develop personnel for added responsibilities.

BOEING

Seattle • Wichita • Cape Canaveral

☐ **Better family living.**

Boeing headquarters are located in the evergreen Puget Sound area, world famous for fresh and salt water boating, fishing, hunting, camping, scenic forests and dramatic snow-capped mountains one hour away offering six-months-a-year skiing. Per capita boat ownership is America's highest. Climate is mild the year 'round, with average minimum temperature of 46.3°. Area is also noted for beautiful modern homes, outstanding schools and universities, cultural activities, unexcelled shopping facilities. At Boeing you work your best and play your best, because both career and living conditions for the whole family are ideal.

There is more to getting ahead in engineering and science than one's own ability. Of almost equal importance is the environment in which you work. If, in your mind, there is any lingering doubt that your present surroundings do not meet *all* the requirements for achieving your fullest professional growth, it will pay you to check the advantages Boeing can offer.

Electronic-Electrical Engineers

Write today for details of challenging, long-range positions available to you right now at Boeing. You'll find at Boeing a dynamic professional environment that's conducive to rapid advancement and deeply rewarding achievement.

Mr. Stanley M. Little,
Boeing Airplane Company,
P. O. Box 3822 - EEA, Seattle 24, Wash.

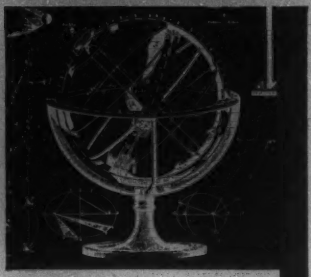
Send me details of electronic-electrical positions, and the booklet, "Environment for Dynamic Career Growth."

Name .....

Address .....City.....State....

Degree(s) .....

Field of Interest .....



Back at the earth terminal..

DOUGLAS AIRCRAFT COMPANY
MISSILES AND SPACE SYSTEMS

has immediate openings in the following fields—

Electrical and Electronics:
Control System Analysis & Design
Antenna & Radome Design
Radar System Analysis and Design
Instrumentation
Equipment Installation
Test Procedures
Logic Design
Power System Design

Mechanical Engineering—
Analysis and Design of the following:
Servo Units
Hydraulic Power Systems
Air Conditioning Systems
Missile Launcher Systems
Propulsion Units and Systems
Auxiliary Power Supplies

Aeronautical Engineering:
Aerodynamic Design
Advanced Aerodynamic Study
Aerodynamic Heating
Structural Analysis
Strength Testing
Dynamic Analysis of Flutter and Vibration
Aeroelasticity
Design of Complex Structure
Trajectory Analysis
Space Mechanics
Welding
Metallurgy

Physics and Mathematics:
Experimental Thermodynamics
General Advanced Analysis in all fields
Computer Application Analysis
Computer Programming and Analysis
Mathematical Analysis

For full information write to:

Mr. C. C. LaVene
Box 620-Q
Douglas Aircraft Company, Inc.
Santa Monica, Calif.

Trade Literature...

Magnetic Starter Catalog . . .

A colorful 16-page catalog, 14-B1, introduces a completely redesigned line of magnetic starters through 15 hp, 440 to 550 volts. Simplicity of construction and elimination of many parts assures long, trouble-free operation. **Furnas Electric Co., 1063 McKee St., Batavia, Ill.**

Welding Equipment Catalog . . .

All Hobart arc welding machines are described and illustrated in a 24-page, 2-color catalog that includes complete specifications and ordering information on gasoline and diesel-engine-driven welders, engine-driven welder-power combination units, electric-motor-driven arc welders, rectifier-type welders, transformer-type welders, combination transformer-rectifier-type welders, a-c and d-c inert-gas shielded arc welders, and a complete line of automatic and semiautomatic welding equipment. **Hobart Brothers Co., EW-209, Troy, Ohio.**

Universal Power Control Units . . .

A line of power control units utilizing magnetic gating amplifiers driving silicon controlled rectifiers is described in Bulletin No. S-1075, entitled "Universal Power Control Units." Described are the five different control system types offered in the new line. The devices, designed for proportional or switching control, are used for both 60- and 400-cps systems, and are said to satisfy 95% of power control requirements. **Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N.Y.**

Instrumentation Recorder Brochure . . .

A 4-color brochure on the Ampex *FR-600* instrumentation recorder, which offers a frequency response to 250 kc in direct recording and to 20 kc in FM work, includes the many revolutionary features of the machine, such as air lubrication of the magnetic tape and removal of the heads from the tape except during record–reproduce or search modes. Full specifications are included. **Ampex Instrumentation Advertising, 934 Charter St., Redwood City, Calif.**

Construction Services Brochure . . .

A 2-color, 16-page brochure, Bulletin 107, illustrates and describes complete installation through start-up service for automation and instrumentation systems of Panellit Service Corp. Services include a contract organization furnishing installation drawings and installation of the panels, field instruments, the field interconnections, commissioning, operator orientation, and providing supplementary instrumentation personnel where needed. **Panellit Service Corp., division of Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.**

Aluminum Alloy Lighting Catalog . . .

A 32-page 2-color catalog on the HAPCO line of aluminum alloy lighting standards contains detailed descriptions, specifications, dimensions, and illustrations on lighting standards with various bracket styles, flood lighting standards, lamp posts, and traffic poles. Advertising Department, **Hubbard and Co., 200 S. Michigan Ave., Chicago 4, Ill.**

Sample Grommet Card . . .

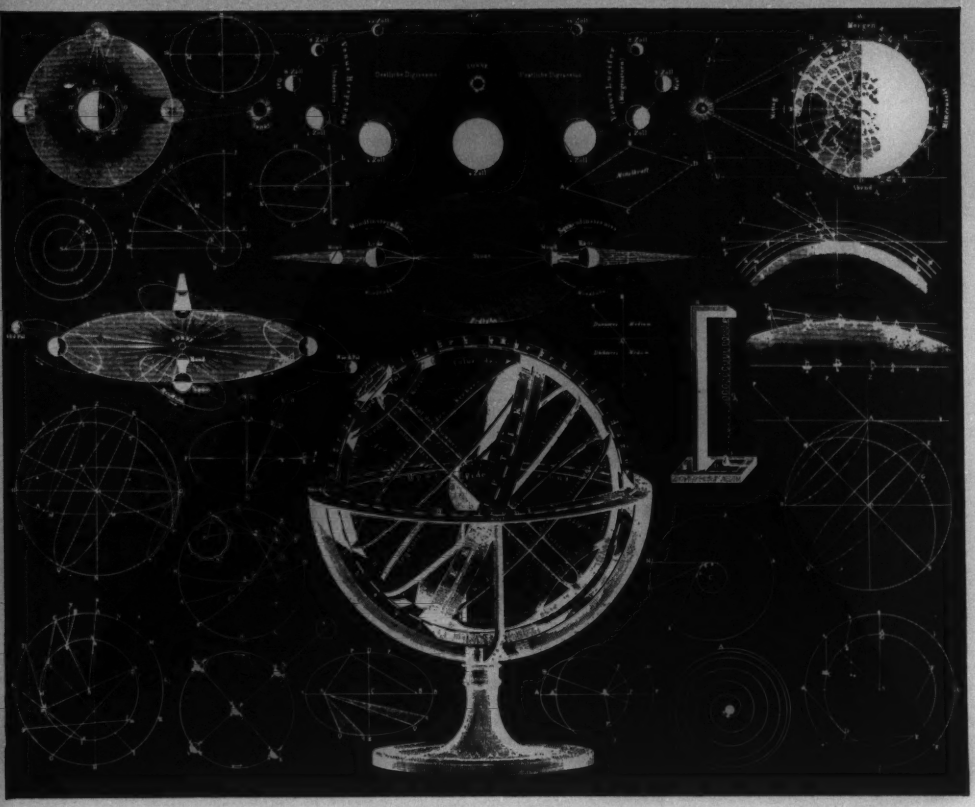
A sample card holding three 1-piece, solid nylon Flip grommets is available free on request from Western Sky Industries. One of the grommets, hung on a key chain, is open, the other two, in white and color, are installed through holes in the card just as in regular installation. This provides an excellent opportunity for study of the design and advantages of these new

grommets. A 2-color imprint on each side of the heavy laminated plastic card identifies the items and lists such salient features as their installation with simple tools at room temperature, refusal to shake loose or pop out, strength, wear resistance without abrasion, insulative qualities, etc. **Western Sky Industries, 21301 Cloud Way, Hayward, Calif.**

Measuring Instruments Catalog . . .

The 1959-60 Guide and Catalog of Precision Measuring Tools and Instruments, consisting of 96 fully illustrated pages, contains complete detailed information on Scherr measuring tools and toolroom specialties. Also illustrated is a complete line of Zeiss indicating micrometers and comparators, Zeiss orthotest, Scherr microprojector, Cycloptic stereoscopic microscope, Scherr toolmakers' microscope, spur gear tester, Parkson gear tester, Kesel circular and linear dividing machines, profiling, engraving, and milling automatics, Cima universal gear hobber, Cornelis thread-generating machine, Opto tooling auto collimator, OMT optical rotary indexing table, Zeiss optical precision measuring instruments. **Scherr-Tumico, 200 Lafayette St., New York 12, N. Y.**

(Continued on page 60A)



Guided tour of the solar system

The new NASA Thor-boosted research rocket, DELTA, now being constructed by Douglas, will set up big signposts for further space explorations. Combining elements already proved in space projects with an advanced radio-inertial guidance system developed by the Bell Telephone Laboratories of Western Electric Company, DELTA will have the versatility and accuracy for a wide variety of satellite, lunar and solar missions. Douglas insistence on reliability will be riding with these 90 foot, three-stage rockets on every shoot. At Douglas we are seeking qualified engineers to join us on this and other equally stimulating projects. Some of our requirements are listed in our column on the facing page.

Maxwell Hunter, Asst. Chief Engineer—Space Systems, goes over a proposed lunar trajectory with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

YOUR CAREER!

Does it still hold its stimulating challenge? Are all of your abilities being utilized? Have you gone far enough, fast enough?

Today, Motorola's rapid expansion in the Chicago area has created an immediate need for experienced engineering talent. Never before have secure career opportunities been more abundant, challenging and rewarding—in a wide selection of electronic fields.

A picture-packed 36 page booklet is waiting for you. It details the work, the people, the living at Motorola. If you are sincerely seeking broader career opportunities and responsibilities, investigate Motorola immediately.

- Radar transmitters and receivers
- Radar circuit design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstrom, traveling wave tube and backward wave oscillator
- Display and storage devices

2-WAY RADIO COMMUNICATIONS

- VHF & UHF receiver
- Transmitter design and development
- Power supply
- Systems engineering
- Antenna design
- Selective signaling
- Transistor applications
- Crystal engineering
- Sales engineering
- Design of VHF & UHF FM communications in portable or subminiature development
- Microwave field engineers
- Transistor switching circuit design
- Logic circuit design
- T.V. circuit design engineering
- Home radio design
- New product design
- Auto radio design
- Mechanical engineering
- Semi-conductor device development
- Semi-conductor application work

Also splendid opportunities in

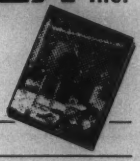
Phoenix Ariz., and Riverside, Calif.

EQUAL JOB Opportunity For All Qualified Applicants

MOTOROLA Inc.

Mr. L. B. Wrenn, Engineering Personnel Mgr., Dept. A
4501 Augusta Blvd., Chicago 51, Illinois

Without obligation, send copy of "Selecting an Engineering Career with a Future"



NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Trade Literature

(Continued from page 58A)

Coaxial Connector Manual . . .

To simplify specifying and ordering of r-f coaxial cable connectors and expedite their delivery, Gremar Manufacturing Co. has compiled a comprehensive cross-reference manual in the field. It is available, free of charge, to qualified design engineers and purchasing department personnel. Each copy of the 46-page reference manual is registered and kept up-to-date by page additions and revisions sent to users. For a free copy of the manual, write on company letterhead to Dept. EE, **Gremar Manufacturing Co., Inc., 7 North Wakefield Ave., Wakefield, Mass.**

Analog Computer Literature . . .

"Analog Computer *CM-2*," a 2-page brochure describes and illustrates this solid-state computing device for mathematical calculations, especially applicable in the chemical, petrochemical, refining, and process industries. It lists all technical data and specifications, including special amplifiers and networks which are available. Copies from **Southwestern Industrial Electronics Co., a division of Dresser Industries, 10201 Westheimer Rd., P.O. Box 22187, Houston 27, Texas.**

Safety Manual . . .

Recognizing safety as essential to its employees, quality production, and efficient operation, American Viscose Corp. has published a detailed 24-page safety manual to be issued to all personnel. The handbook is a composite of supervisor-employee ideas on safety, in addition to established safety principles. Much of the data originated in the corporation's plants, and realistic safety practices for accident prevention, especially geared to plant activities, are presented. Industrial Relations Dept., **American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.**

"Writing and Publishing Your Technical Book" . . .

This comprehensive and informative book is available to anyone requesting a copy from Dodge Books, **F. W. Dodge Corp., 119 W. 40th St., New York 18, N. Y.**

Booklet on Safety Lighting . . .

There is evidence of need by the traveling public that certain sections of the new Interstate Highway System be equipped with fixed roadway lighting. This booklet, entitled "Guide to Nighttime Highway Safety" gives the facts about the annual toll of nighttime accidents and deaths, and suggests a preventive program. **Safety Lighting Bureau, 1400 Terminal Tower, Cleveland 13, Ohio.**

(Continued on page 65A)

QUALIFICATIONS: B.S. or advanced degree in Electrical or Mechanical Engineering, Physics or Mathematics—and proven ability to assume a high degree of technical responsibility in your assignments.

TYPICAL ASSIGNMENTS

Planning and logical design of solid state computers, input-output systems, and peripheral equipment. Knowledge of digital systems required with experience in transistor circuitry and switching techniques.

Analysis of ferrite "memory" and buffer systems and design of new high-speed configurations, including drive and addressing circuitry, for advanced solid state data processing systems. Familiarity with digital computer systems and magnetic core "memory" design.

Solutions of real-time control problems with digital techniques; mathematical analysis of navigation and fire control systems, ray tracings, and signal cross-correlations.

Application of information theory to signal processing. Familiarity with signal cross-correlation techniques, statistical data processing, sampled-data control theory, analog-digital data processing techniques, signal propagation, and beam formation. Naval experience required in at least one of these specialties: sonar, fire control, ASW, navigational systems, signal processing.

Investigation of new computer applications and techniques, based on observation and analysis of customer needs; establishment of broad systems concepts, assisting in both logic and machine design. Experience required in digital computer applications, technical organization of a medium or large machine installation.

Circuit design of advanced data processing systems and input-output equipment, working closely with logic designers. Experience required in design of arithmetical control and switching circuitry to reduce logic diagrams to component counts for cost-estimating development.

Application of transistor-diode logic to develop advanced circuitry; review of new circuits for possible use in digital control systems, defining basic techniques for improving performance characteristics.

Laboratory facilities are located in Endicott, Poughkeepsie, Kingston, Owego, and Yorktown Heights, N. Y.; Lexington, Ky.; and San Jose, California.

For details, write, outlining background and interests, to:

Mr. R. E. Rodgers, Dept. 550L
IBM Corporation
590 Madison Avenue
New York 22, N. Y.

CAREERS ALSO AVAILABLE IN THESE AREAS . . .

Acoustics
Applied mathematics & statistics
Applied physics
Circuit design & development
Component engineering
Computer analysis
Cryogenics
Flight test analysis
Human factors
Inertial guidance
Information retrieval
Logical design
Magnetics
Microwaves
Operations research
Programming
Radar circuitry
Transistor circuit design

IBM®

INTERNATIONAL BUSINESS MACHINES CORPORATION

Trade Literature

(Continued from page 60A)

Pocket Guide on Welding Wires . . .

A newly revised edition of Air Reduction's Aircomatic welding wire pocket guide (Form ADC 873A) has been brought completely up-to-date to include the latest information on Airco's line of gas-shielded metal-arc welding wires, including data on the improved *A675* steel wire, and the *A666* steel, and *A556* aluminum. **Air Reduction Sales Co., a division of Air Reduction Co., Inc., 150 E. 42nd St., New York 17, N. Y.**

Reprint on New Reproducing Techniques . . .

New techniques used by the U. S. Navy to produce printed matter from punch cards and to store whole pages or forms on microfilm inserted in aperture cards are discussed in a 12-page reprint. Called "A Line, A Page, A Publication—The Navy's New Design in Printing," the article was prepared by A. N. Spence, director of publications, U. S. Navy. The reprint is heavily illustrated and takes the reader through all the steps from line composition, to page formulation, to completed publication, and lists in detail the various equipment the Navy has used. The reprint itself was partially produced by this method and is representative of its characteristics. **The Filmsort Co., division of Michle-Goss-Dexter, Inc., Pearl River, N. Y.**

Hysteresis Synchronous Electric Motors Brochure . . .

Features of a new line of extreme precision hysteresis synchronous electric motors for use in tape transports, turntable drives, missile and aircraft instrumentation, computer drum drives, flow meters, etc., are explained in a 4-page, 2-color illustrated brochure. The brochure details performance characteristics and dimensions in picture and chart form as well as describing construction and design features and characteristics. **Hysyn Electromotive, a subsidiary of Telecomputing Corp., 915 North Citrus Ave., Los Angeles 38, Calif.**

Marathon Pen Brochure . . .

A descriptive brochure pointing up the unique features of Marathon long line and wide line ruling pens is available from Keuffel & Esser Co. Marathon pens offer a distinct advantage over ordinary ruling pens by drawing from 5 to 8 times more inches of line per filling. For example, No. 9 width pens will rule about 45 feet of line in contrast to ordinary pens, which rule about 6 feet of same width line. Marathon ruling pens are made in six fixed widths. **Keuffel & Esser Co., Adams and Third Sts., Hoboken, N. J.**